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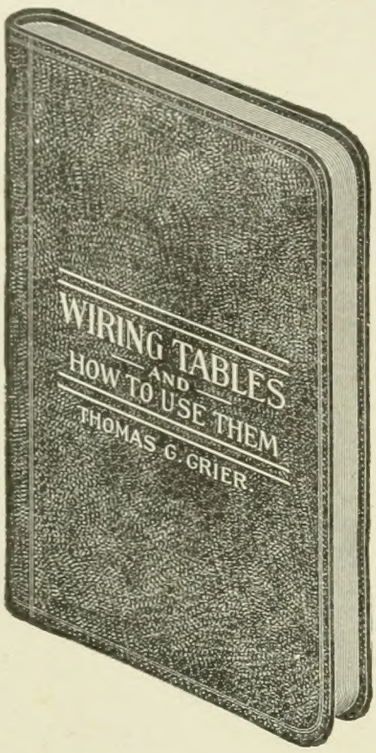

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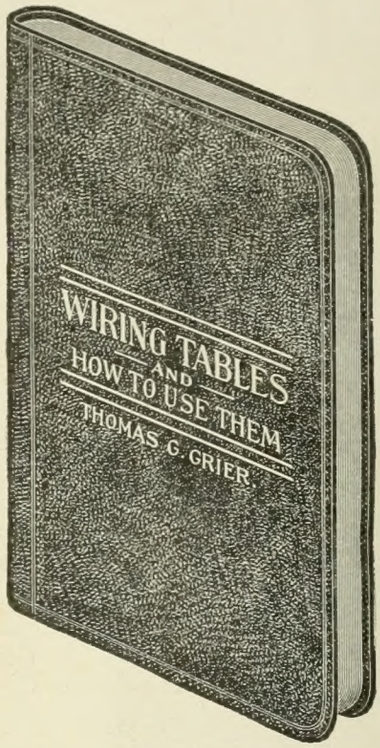

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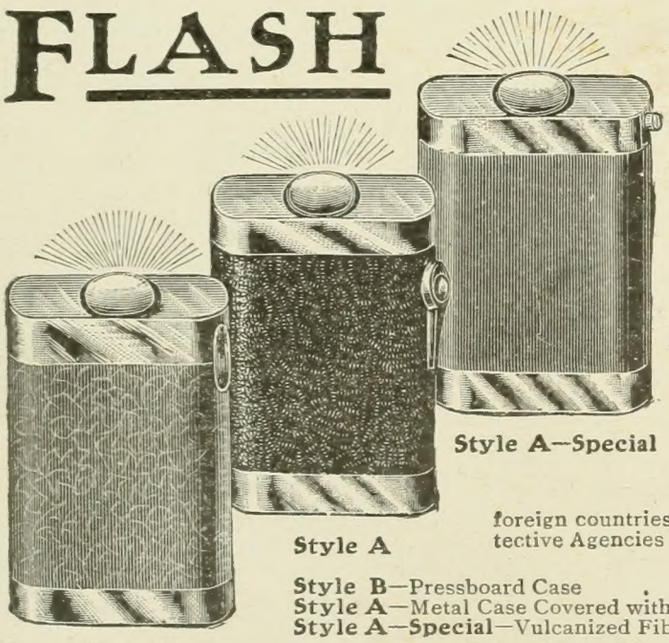

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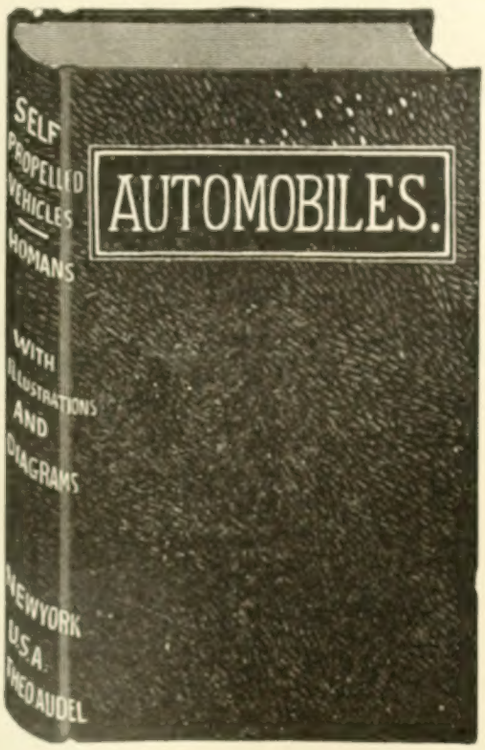

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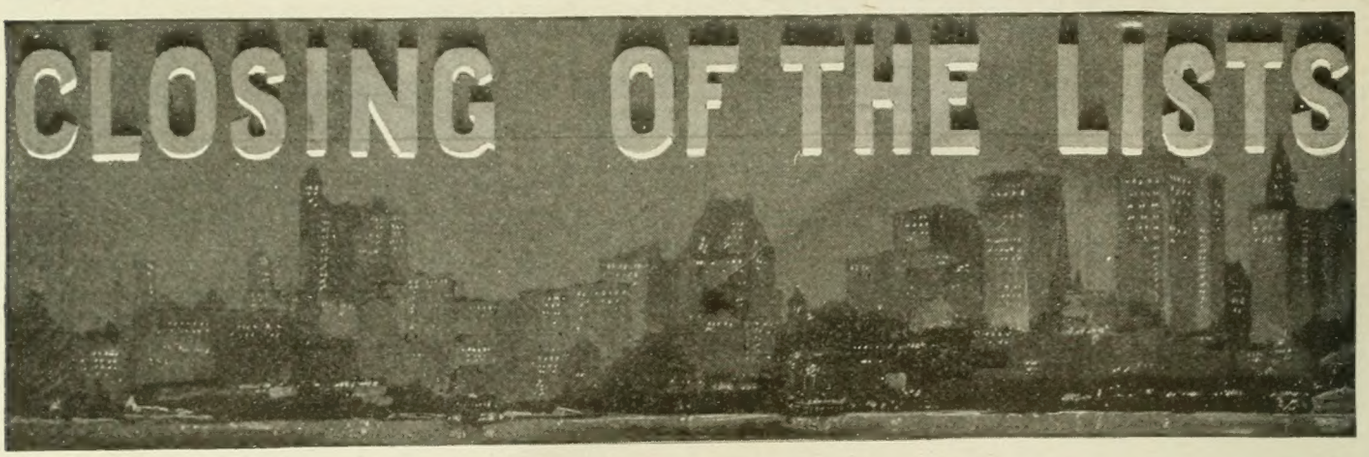

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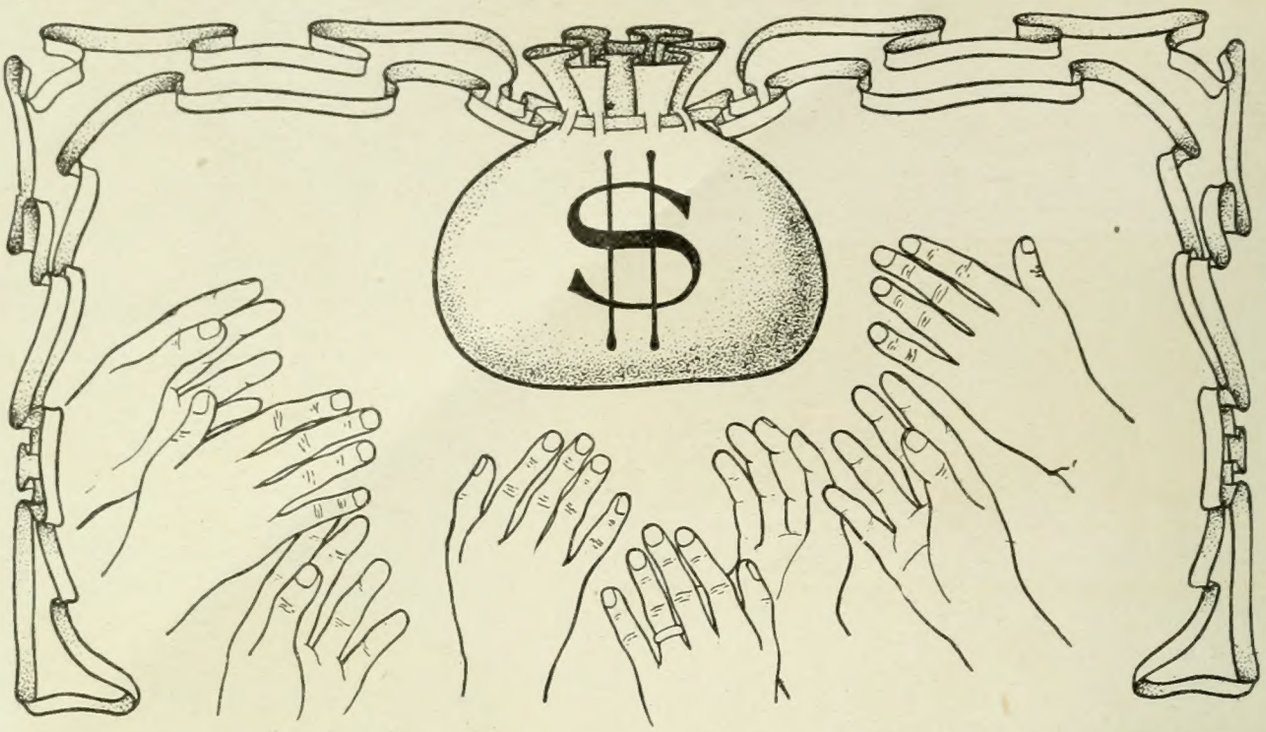

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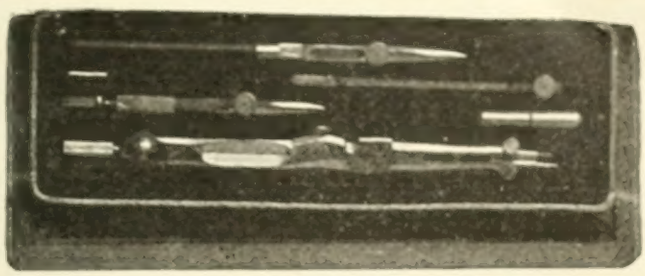

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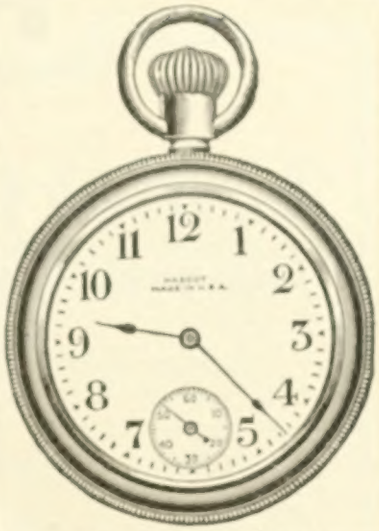

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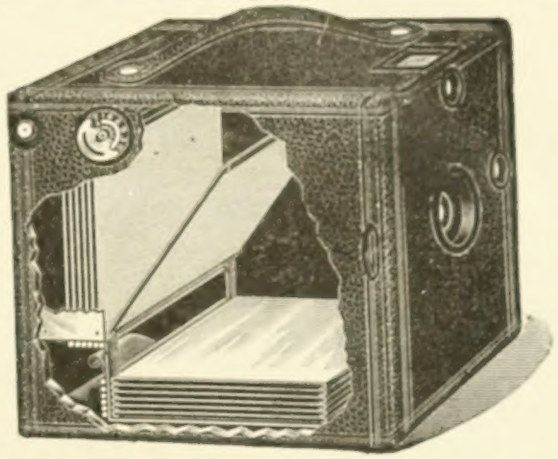

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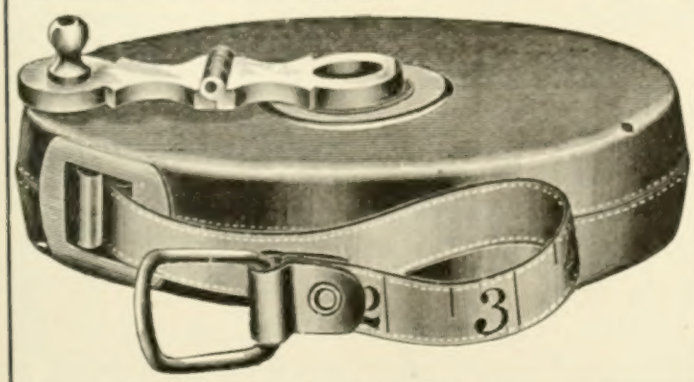

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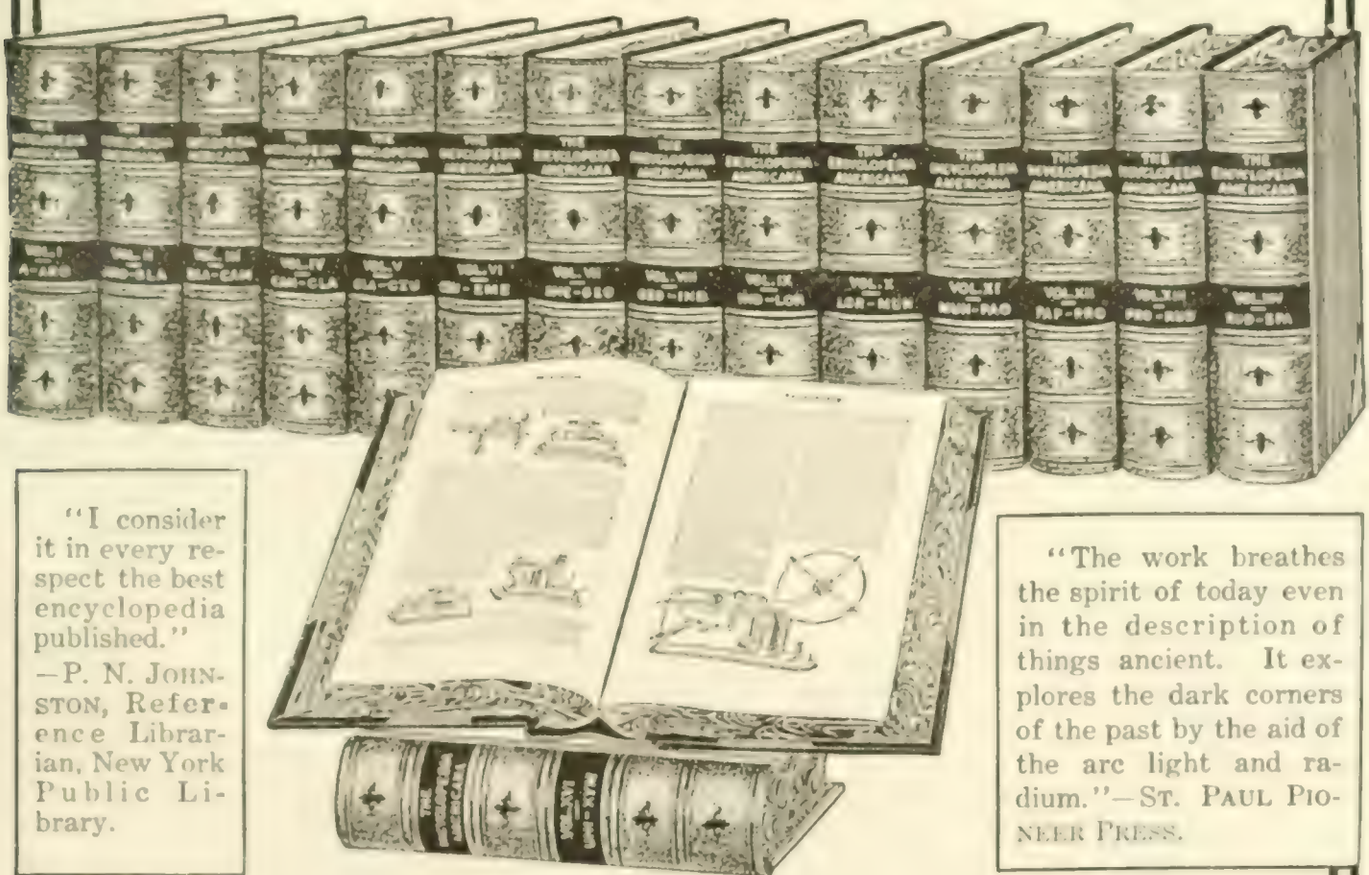

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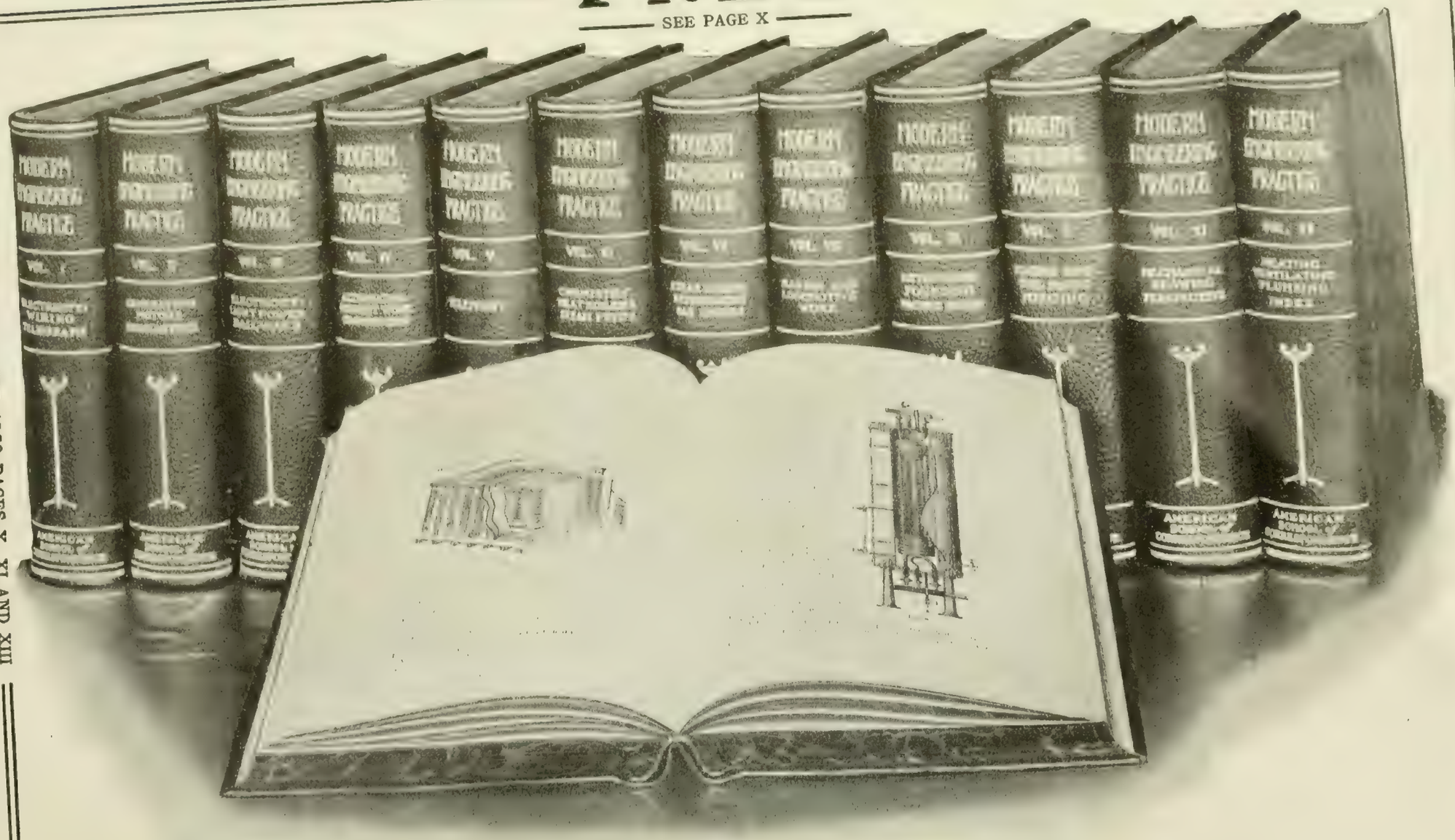

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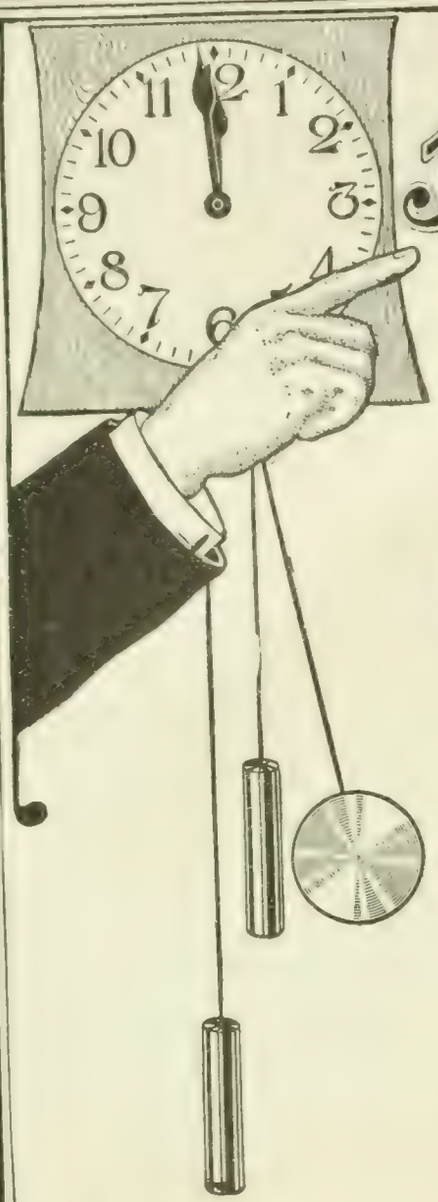

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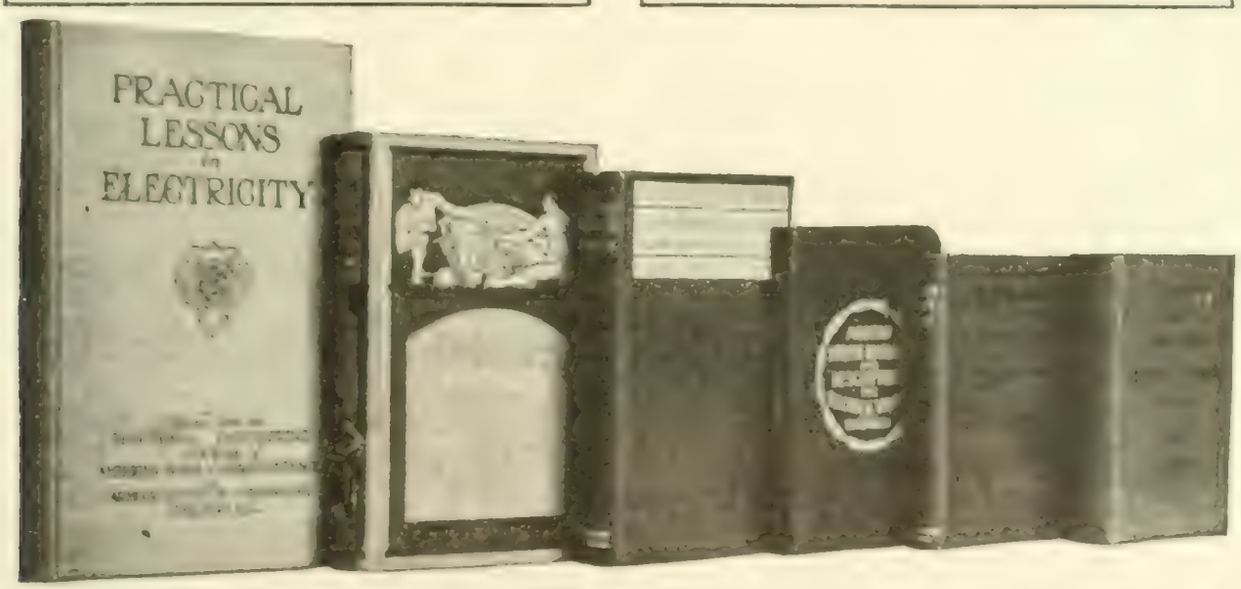

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The
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Volume III MAY, 1905 No. 1

Marvels in Tunnel Building About New York City

The Development of New and Successful Methods of Tunnel Construction

By WILLIAM R. STEWART

THIRTY years ago last September, a company of American capitalists undertook to build a tunnel under the Hudson River between New York and Jersey City. It ran out of funds and failed. Six years later some British capitalists undertook to complete the enterprise. They drove the boring 1,800 yards further into the clay and silt; and again disaster, financial and engineering, overtook the promoters. In 1890 another English company, with a board of titled directors, succeeded in adding 895 feet to the total length before it too gave up the task. Five million dollars were sunk in these attempts, more than one hundred lives were lost, and only a charter and a half-dug passage remained as evidences of the efforts which had failed.

On October 22, 1902, a fourth company began work where the third had left off; and on March 11, 1904, the last ring of the cast-iron casing plates was riveted into place, and a party of engineers, financiers, and railroad officials made the first trip on dry land under the Hudson.

The result marks the advance in tunnel engineering of the twentieth century over the nineteenth. By none of the methods known up to 1902 could the tunnel now being driven under three rivers at New York have been completed, except at an expenditure in money vastly exceeding that now required, and at a cost of lives still more disproportionate. As compared with the casualty list of more than a hundred, during the abortive first efforts at digging beneath the Hudson, not a single workman has lost his life during the present successful operations.

Two innovations in particular stand out from among the many improvements in methods of tunneling which the present wonderful era of subterranean boring in and around New York City has brought about. They are the shield method with compressed air, employed by the New York & New Jersey Railroad Company and the Pennsylvania Company, underneath the Hudson River; and the method employed in constructing the city's subway under the Harlem River, which consists, in brief, in building the heavy arched roof of the tunnel on a pontoon, then launching it and sinking it on a foundation of piles and a

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BLASTING IN TUNNEL CONSTRUCTION.
In the foreground the men are removing debris; in the background are pneumatic drills at work drilling holes for new blasts.

specially prepared sheeting of heavy timber. Both of these improvements—one the invention of an English engineer, who had gained his experience in the United States; the other, of an American engineer—have revolutionized in important respects the building of sub-aqueous tunnels.

Interest in the progress and recent completion of the rapid transit subway in New York has been so great that the other tunnel projects, all designed to let the great community out from its prison doors, have received little public attention. Yet there is an army of delvers still beneath the city streets; and under the East River and the Hudson are being pushed, by day and by night, enormous steel tubes, burrowing their silent, resistless way through the mud, as a worm might force a path through a sand hill. Under the East River two tunnels from Battery Park to Brooklyn will connect the rapid transit systems of the two boroughs; and another tunnel, that of the Pennsylvania Company, will annex Long Island to the "continent." Under the North River the twin tunnels of the New York & New Jersey Railroad Company, and the double-track tunnel of the Pennsylvania Railroad, will abolish that waterway as a barrier traversable only by ferry.

The New York and New Jersey Tunnel

The New York & New Jersey's tunnel is not so great an enterprise as that of the Pennsylvania, but to it belongs the distinction of having seen the first application of the shield method, which is being employed in both. As has been said, this method is the invention of an English engineer. In 1880, Charles M. Jacobs came to New York for the English company which undertook to tunnel the Hudson. He went back to England beaten, but one day the idea came to him to push a steel tube by hydraulic pressure under the river. In 1902 he came over again, and did it. He is now chief engineer not only for the New York & New Jersey Company but for the Pennsylvania Company as well.

The Hudson River at New York, where the New York & New Jersey's

tunnel crosses it, is 75 feet deep in the main channel. For thirty-five feet below that, the soil is a soft, compact clay silt, interspersed with rock. The need of building the tunnel as near to the surface as possible, to avoid too steep a grade, made it necessary to drive it through the soft silt on top of the firmer substratum, and this presented the chief difficulty in the engineering problem.

When the earlier efforts at tunneling under the Hudson were made, the methods of air pressure and timber bracing were nearly as good as they are now, but the methods of excavation and tunnel-lining were much inferior. Picks and shovels then took the place of the power-driven cutting shield of to-day. Instead of being able to follow such a shield with the tunnel lining, as is now done, the older workmen relied on the pressure in the air chambers to drive back incoming water, and in a measure also to sustain the unlined walls. Timber bracing and brick work were used as further supports. Leaks were numerous, and sometimes the river water broke in and the workmen were drowned.

The shields, which have changed all these conditions, are constructed of boiler plate, strengthened by massive steel webs and divided into compartments. They are thirteen feet in length by twenty feet in diameter, with a hardened steel cutting edge fifteen inches long and three inches thick at the working end. Behind this comes what is known as the outside diaphragm, which has several openings to let in the mud which is displaced by the shield's advance. The entire shield is forced forwards by hydraulic jacks with a pressure of about 2,000 tons.

As the shield is advanced by this enormous pressure upon it, it forces the silt to either side and upward—as one might push a stick through a cheese. As the shield progresses—twenty-five inches at a time, in about forty minutes—a ring of cast-iron plates, the permanent lining of the tunnel, is forced into place behind it by hydraulic pressure, and riveted in position.

EXCAVATING AND REMOVING DIRT AND ROCK.
A typical scene in the construction of New York's great subways.

The method by which the shield is forced forward and the rings of the tunnel lining bolted into position behind it, will readily be comprehended, even by the non-technical reader. The operation is simplicity itself. As has been said, the shield is thirteen feet long, the front part being armed with the ordinary cutting edge running around the rim. Five feet from the after end of the shield a wall is constructed; and around the inner circumference are sixteen hydraulic jacks, each capable of exerting, if necessary, a pressure of 5,000 pounds to the square inch. Using the completed tunnel behind as a base to push against, the shield is driven forward through the river mud, which it forces away on every side. As the five-foot space behind the after wall of the shield fits over the end of the tunnel proper like a cap, keeping the whole water-tight and clean, all that the workmen have to do is simply to bolt the sections of the tunnel together as the shield advances and leaves within its tail the space for a new ring. Each ring is two feet wide; and the rings are bolted together through flanges that run along their edges.

The power which works the jacks and pushes the shield along its course, comes from hydraulic engines at the top of the shaft at the New Jersey side of the tunnel, and is conducted to the valves of the jacks through a three-quarter-inch pipe. When the shield has been forced from shore to shore, the tunnel is ready for trains. There is no ballasting to be done, no calking, nor other finishing touches. The tracks have kept pace with the tunnel, as the tunnel has with the shield.

LOOKING NORTH IN 34TH STREET TUNNEL, NEW YORK CITY.
In central foreground is a manhole, showing ends of electric cable conduits.

The single dramatic element in the steady, systematic advance of the great shield, is involved in the fact that between the lining of its tail end and the permanent lining of the tunnel there is always a space of an inch or more which is left unprotected; and where the mud covering of the river bed is very soft, and the bed itself is not far off, there is danger of the compressed air from within blowing the silt away and leaving an

aperture open to the direct action of the water, against which the compressed air would be no protection.

Early in 1893, when under the middle of the river with seventy-five feet of water overhead, the shield in the first of the New York & New Jersey Company's tunnels encountered a ledge of rock and was injured. The work was delayed while a bulkhead was built out in front of the shield and the shield repaired. Pressing for eleven days against the little strip between the shield and the last plate of the tunnel, the compressed air one day forced the opening clear of earth, and the men were face to face with the river. The seam was effectively stopped up with bags of sawdust and rags; but could the shield be moved ahead the full remaining distance till the permanent lining could be forced in behind it?

A chance which was almost desperate was taken. Full air pressure was turned on, and a battle with the Hudson began. As the shield slowly advanced the water began to pour in around the brim. The men jumped to the sawdust bags which had been provided, and began pushing them against the widening opening. As

NORTH RIVER TUNNEL.
View showing portion of work first completed.

INTERIOR OF APRON IN FRONT OF BORING SHIELD.
View taken five minutes before a shove was made.

the shield moved on an inch at a time, the water increased in volume; and when fifteen inches had been traversed the men were in water up to their knees—twenty inches; and coats, vests, and shirts were stripped off to supplement the sacks in the breach. Then came the final two inches, and as the last sacks were not enough, two of the workers seized another of their number and thrust him bodily into the opening and held him there. Then the plates were lifted and bolted into place. Three times the battle was repeated before the doors back of the cutting block were forced open by the mass of mud they encountered.

The bed of the Hudson is not all soft mud, and the presence of occasional rocks has created some interesting problems. In building the north tube of the New York & New Jersey tunnel, the workmen came upon a mass of rock about 800 feet through. How to penetrate this, was solved by building trap doors in the shield, which formed aprons over the heads of the workmen, through which they could drill the rock and blast it, always being protected by the shield's bulkhead, and with the completed steel-walled tunnel back of that. One day the workmen came upon a monolith which was the occasion of much perplexity, and also of another innovation in tunnel operations. Every known method for establishing a firm bed on the river bottom overhead, in order to prevent the water from leaking down upon them, was tried; but still the water poured through. Boatload after boatload of clay was dumped overboard from scows in the river, but to no avail. Finally the experiment was tried of turning an immense flame on the clay from underneath. The experiment was completely successful: the clay was completely vitrified, and a perfect roofing was formed.

Sanitary conditions in the tunnels now being constructed around New York have kept pace with the advance in engineering methods. Transportation in the tunnels is by electric motors; and, as all the lighting is electric, the air remains comparatively pure. Workmen are never permitted to go immediately from the compressed air-locks into the open air, but are required to pass through compartments which prepare them gradually for the change. Nor is there a possibility

of the occurrence of any accident of which news could not be communicated instantly. All along the line of the tunnel are installed, as fast as the iron rings are put in place, electric wires communicating with the exit and with the chief engineer's office in New York city. Sitting in this office, Mr. Jacobs can talk by telephone with any workman digging in the shield fifty feet or so under the bed of the river.

The same method employed in pushing the tunnel under the river will be used in constructing the new subway under Sixth Avenue. Already more than a thousand feet of tunnel have been constructed in this manner while a steady stream of street traffic has been in progress overhead. Many feet below the surface of Morton and West Tenth streets, in Manhattan, the steel shield, with the iron rings following it, has worked its way underneath the tracks of the New York Central Railroad, with heavy freight trains passing along them; under the supports of the elevated railroad structure; and past the foundation piers of great buildings.

The total length of the New York & New Jersey tunnel is 9,200 feet, 5,000 of which are under water. One tube, the northern, is eighteen feet in diameter, and the other, fifteen feet. Special fireproof cars are being constructed for the train service; and the running time from terminal to terminal will be seven minutes, with a train every minute.

The Pennsylvania Tunnel

The Pennsylvania Railroad's tunnel which from its Hackensack portal to its exit on Long Island will be a trifle under six miles long, is being pushed underneath the Hudson by practically the same methods as those employed by the New York & New Jersey Company. There is this difference between the two, however, that the Pennsylvania tunnel will pass almost entirely through silt; and although this is sufficiently firm to preserve the tunnel itself in perfect alignment, it was considered that provision should be made for supporting the moving train loads independently of the tunnel shell. The problem thus presented is being solved by driving a line of massive cast-iron screw piles through the floor of the tubes, at 15-foot intervals, with their heads pro-

CLEANING UP AFTER A SHOVE

jecting within the tubes, and by capping the piles with a system of heavy transverse girders and longitudinal stringers, upon which the track rails will be laid. The heavy load of the trains thus will be received by the piles; and any possible slight settlement of them would not affect the tubes, which would act simply as an envelope for the protection of the trains. Of the total of about 25,000 feet of cast-iron single-track tunnel, about 12,000 feet will be reinforced by screw piles.

THE 28TH STREET STATION OF THE NEW YORK SUBWAY.

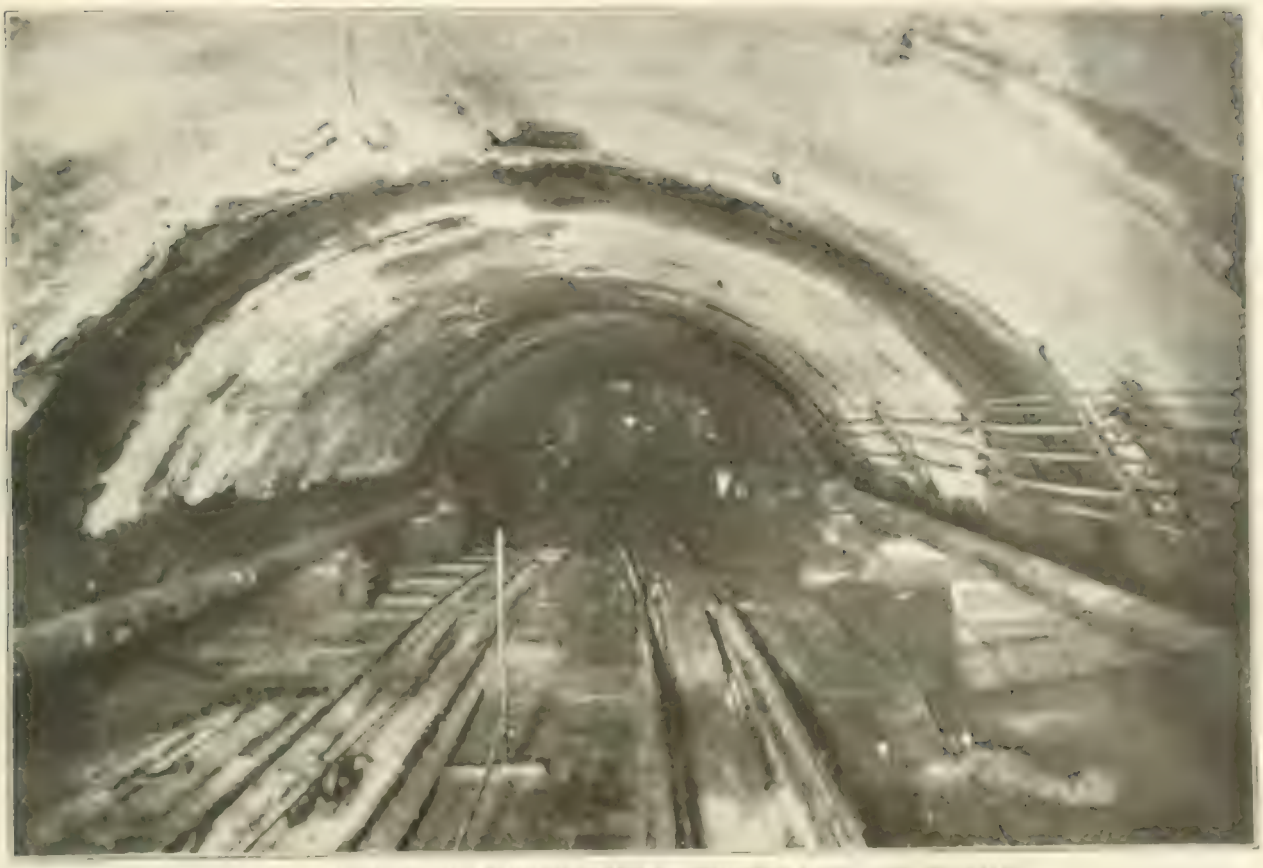
Placing the Piles

The following is the method by which the piles on which the tunnel rests are sunk:

At stated intervals in the shell of the tunnel corresponding to the desired position of the piles, plates are cast with flanged holes. After a certain length of the shell has been driven, it is bulkheaded off, placed under pneumatic pressure, and the piles screwed down from the interior. The piles are 27 inches in outside diameter, and they are made in seven-foot sections. The pile is screwed down by means of a special hydraulic ratchet arrangement bolted to the head of the pile; and, as one section is carried down, another seven-foot section is bolted to it, the process continuing until rock, or at least impenetrable bottom, is reached.

The core of mud inside the hollow pile is excavated for a depth of twelve feet below the tunnel tube, and the space filled in with concrete. After the pile has been driven, the last section is removed, cut to exact length to bring it flush with the floor of the tube, and replaced and bolted. Above the cap of each pile are bolted heavy transverse girders; and upon these girders, bridging the intermediate space of fifteen feet, are a pair of longitudinal girders, upon which the railroad tracks are laid. By this means the weight and impact of the heavy trains are borne directly by the piles.

Without describing in detail the mode of construction being employed in the Pennsylvania's tunnel operations, which would be quite impossible within the limitations of space of the present article, it is interesting to note some of the pre-



TUNNEL UNDER NORTH RIVER—FIRST LOCK—EAST SIDE

cautions which are being taken to provide against the possibility of any form of accident. Fire within the completed tunnel will be impossible. All cars which run through it will be fireproof, and nothing in the tunnel of any description will be inflammable. There will be no connection between the operating power and the electric lighting, so that a break in one will not involve the other. Two concrete sidewalks, on a level with the windows of the cars, will give convenient egress for passengers in case of a breakdown; and the tunnel tubes—of 1¼-inch cast iron, lined with eighteen inches of concrete—will be able to withstand any possible shock to which they may be subjected. The sidewalks also will constitute a channel for the trains, preventing them in case of derailment from coming into contact with the walls. The greatest weight which the tunnel and its supporting piles will have to carry at any one point, will be a 100-ton electric locomotive, distributed over a length of 30 feet.

A New Method of Construction

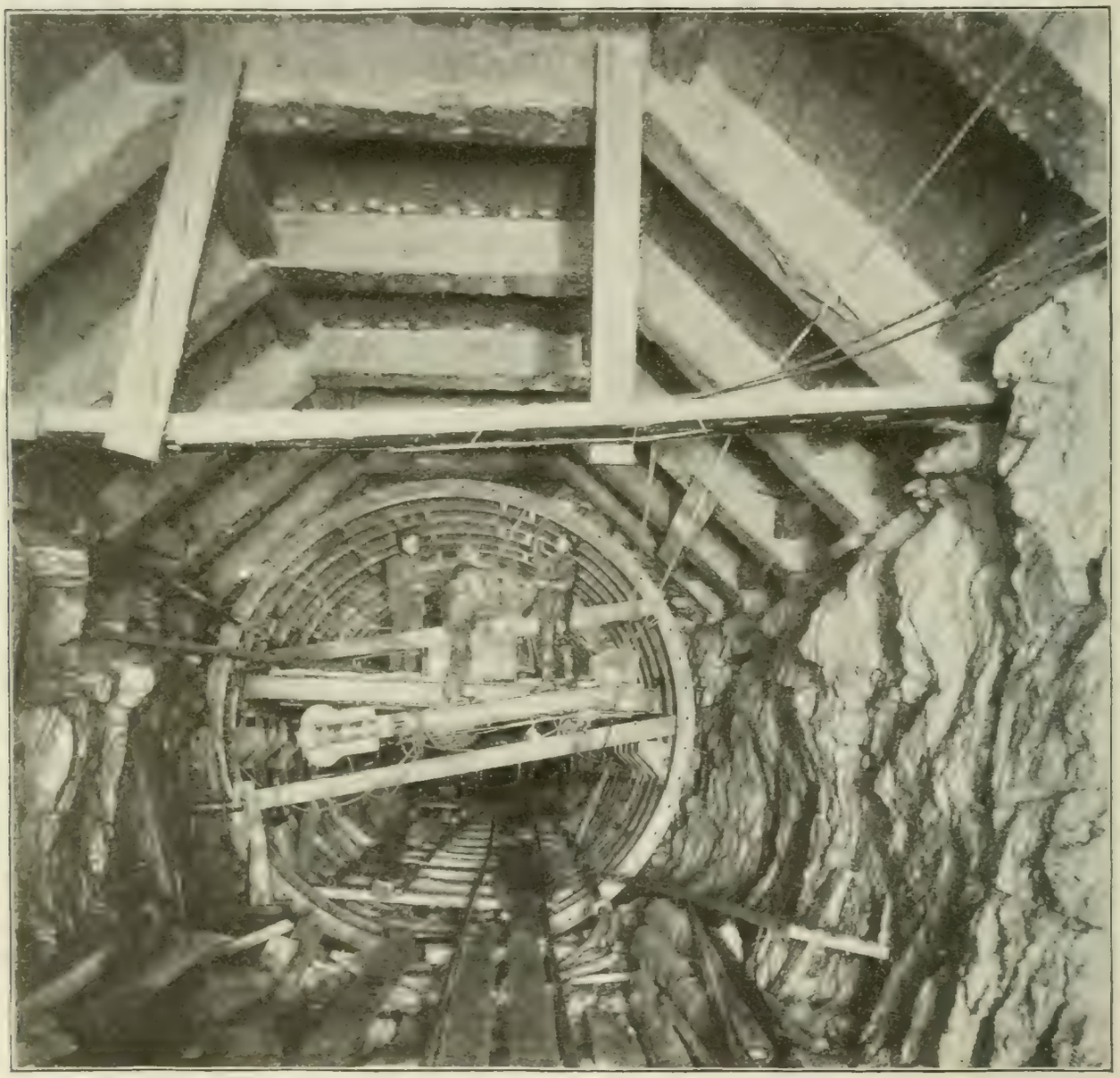
The innovation in tunnel construction which I have mentioned as having been introduced in the building of the rapid transit subway under the Harlem River, is the invention of D. D. McBean, the sub-contractor on that section. It is especially interesting as compared with the shield method employed underneath the Hudson. It is much simpler than the shield method, and can be employed in soft silt which would not withstand the air pressure necessary for the latter. Whether it would lend itself to application under the conditions met with below the Hudson, has not yet been determined by practical test, but there is reason to believe that it might.

The difficulty of constructing the section of the subway under the Harlem which led the contractor to try a new device, lay in the treacherous, quicksand character of the river bed and the many springs there, which rendered the ordinary methods impracticable. At first the method adopted was to dredge the river bottom, and enclose the space for the tunnel by a heavy line of 12-inch piling on each side, on top of which a roof was placed, forming a long, bulkheaded section. This was the process adopted on the Manhattan side. When he came to do the Bronx end, the contractor decided to make the tunnel do some of its own work; and, omitting the wooden roof, he sank in its place the

finished upper half of the tunnel. Then, working under the upper half, and employing compressed air, he built the lower and completing half. The top of the tunnel, which is packed around with concrete, is about 12 feet below the river bed, and 52 feet below high water. It is difficult to describe the actual process of construction followed within the space at command. In its outlines, however, the method is as follows:

A channel was first dredged along the line of the tunnel, along each side of which piling was driven to support two working platforms. In the channel, rows of foundation piles were driven at intervals of eight feet, and cut off about 20 inches below the spring line of the tunnel. The sheet piling was then driven in place to form the sides of the tunnel caisson, a diver being stationed below to ensure proper setting of the piles.

The assembling of the upper half of the tunnel was performed on a pontoon constructed between the working platforms, this upper roof being built in three sections to facilitate handling. The ends of the half-tunnel were closed by vertical diaphragm plates, and the bottom was closed by a heavy wooden flooring. After the metal shell had been covered with concrete, the pontoon was sunk, the tunnel section being lowered into the water until it sank. The pontoon was then drawn out, and loose stone was loaded on the tunnel section, which was



TUNNELING UNDER LOWER BROADWAY FOR RAPID TRANSIT SUBWAY.
The tunnel route here shown in part, extends from the Battery at the lower end of Manhattan Island, across the East River, to Brooklyn.

lowered to position on the sheet piling, careful measurements being taken to bring it to perfect alignment. A diver then removed a plate of the tunnel shell, entered, and bolted the end flanges of the tunnel to the flanges of the shore section. The plate was then again bolted in place, the water was pumped out and air pumped in.

The method just described makes possible easy grades in sub-river tunneling; and tunnels made by it may be of any shape or dimension, with partitions and intercommunicating openings not possible by the shield process.

East Ventilating Tower between the two tunnels.

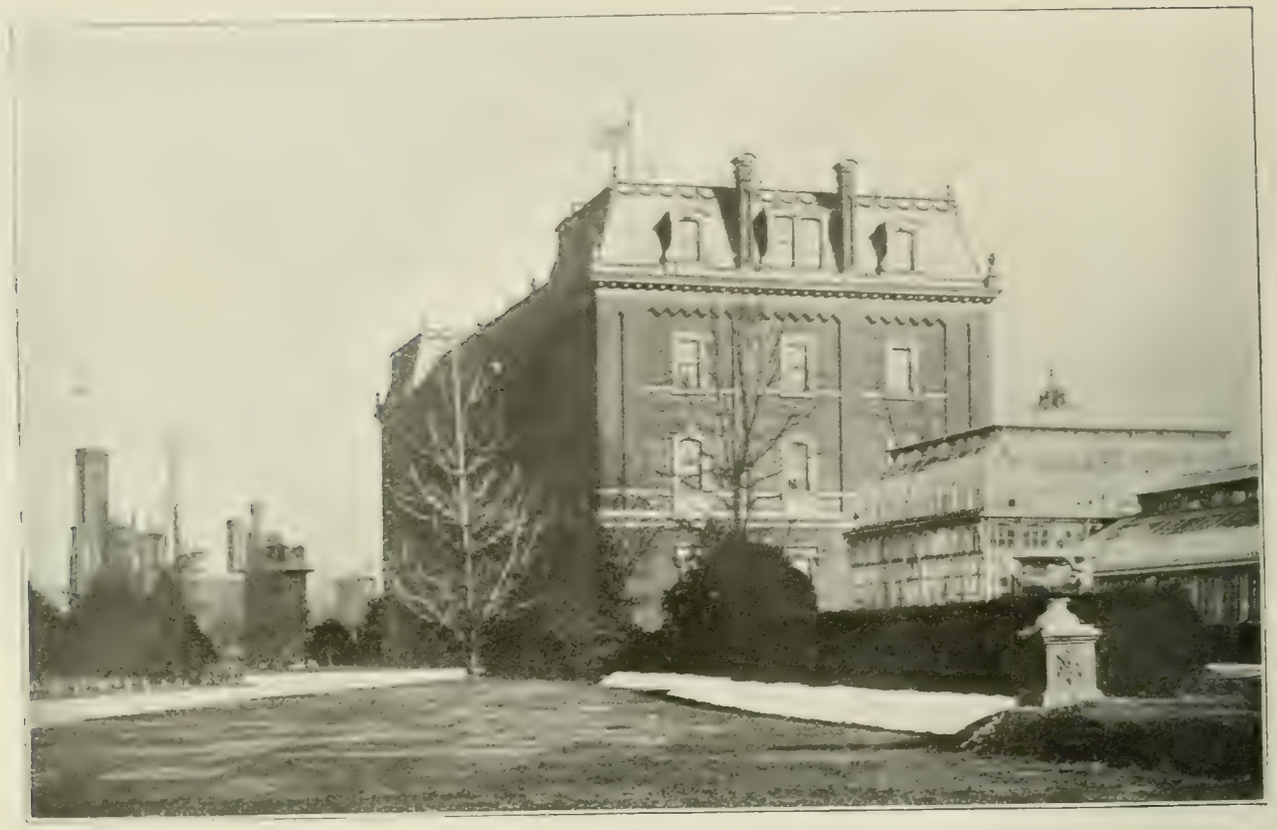
The East River Tunnels

The rapid transit borings underneath the East River are being prosecuted by the shield method. Forty-five borings were first made—from rafts anchored above—in the river bottom, along the proposed line of the tunnel, to ascertain the nature of the ground. Eleven of these were made with diamond drills through rock; and the others were wash-borings. They showed, at a depth of ninety-seven feet below mean tide water, at the middle of the river, that the tunnel would penetrate gneiss rock from the Battery to a point under the middle of the river; and thence sand, with a single spur of rock, two-thirds of the way to the Brooklyn shore. Excavation began early in 1893, and the work will be completed some time next year. Two separate tunnels are being built, of the same type as the New York & New Jersey Company's tunnels.

During the progress of the shield boring in the Brooklyn section some time ago, the compressed air in the chamber literally blew out the river bottom, endangering for a time the lives of the workmen in the tunnel. The trouble was overcome by dropping bags of sand from a vessel anchored in the river overhead until the break was repaired.

Besides the tunnel operations mentioned, two other subterranean projects of considerable magnitude will be begun around New York in the near future. One of these will be a tunnel from Exchange Place, in Jersey City, to Cortlandt Street, in New York, there to connect with the rapid transit subway to Brooklyn and to the Bronx. This will be undertaken by practically the same company as that which is constructing the New York & New Jersey tunnel. A fourth separate tunnel system under the Hudson River has also been projected by the Delaware, Lackawanna & Western Railroad.

U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.
In the background at left is the Smithsonian Institution.



Electroculture

Work of a New Government Laboratory in Forcing Plant Growth by Electrical Treatment

By JOHN ELFRETH WATKINS

ONE of the favorite feats of the Oriental juggler, or so-called "adept," is the planting of vegetable seed which seems to germinate almost instantaneously, developing into a tree or a vine from which burst forth green leaves or blossoms, or, perchance, edible fruit.

Thus to speed the hand of Dame Nature has seemed to the Western tourist a miracle; and science has long pondered over an explanation of the clever "trick," if such it be.

In a modest two-story dwelling, upon the street lining the rear of the United States Department of Agriculture, a corps of Yankee scientists has planned to hasten Nature's hand in plant growth; but it claims no esoteric touch, beyond that of the subtle and unfathomed fluid which we call "electricity."

This little building has been converted into a laboratory of the Bureau of Plant Industry, whose scientists have lately surprised the world through their "invention" of new vegetable species. New apparatus, imported from abroad, is being installed to apply the electric stimulus to soil planted with various seeds, and directly to the growing seedlings themselves.

Dame Nature has, indeed, proved too slow for these progressive days of ours; but who can gainsay that the soil which now gives up one yield of shrub or flower or plant will soon be forced to bring forth several crops each season; or that the agriculturist will before long have learned to realize from each acre of his land several-fold more of profit?

The general investigation of the influence of electricity upon plant growth was begun in this laboratory last autumn; but no information as to results will be communicated to the outside world within the next year, at least. The tests will be entirely along the line of applying electricity directly to the plant, to the soil in

which it knows to the atmosphere surrounding it.

Methods of Experiment

Prof. B. T. Galloway, chief of the Bureau of Plant Industry, has assigned this important work to the directive charge of Chief Albert F. Woods, of the division of vegetable physiology. Chief Woods has imported from abroad a special induction coil for producing the currents with which the plants will be stimulated; a special galvanometer for measuring the current's strength; and a special potentiometer for measuring differences in potentials.

Ingenious instruments—so to speak—for measuring the plant's rapidity of growth, will also be employed. One of these instruments holds the top leaf of a seedling by a clasp; and, as the plant increases in stature, a lever fastened to the clasp moves upward, recording its movement with a fountain pen whose point rests upon a paper record, wound about a drum slowly revolving at a given speed. Thus the investigators may literally see the plant grow. The first tests will be a review of certain preliminary experiments in the same line by foreign plant physiologists. Reports of all such experiments hitherto attempted have been gathered by Chief Woods.

Plants are to be grown in electric batteries. There is found to be in living vegetable life an electrical potential, such as is given off by the electric eel and by other animals, but in much less degree. It is found, for example, that by connecting by wire the two extremities of a seedling of the old world horse bean, an electromotive force of one-tenth of a volt may be obtained.

In the course of the preliminary tests, plants will be electrified by passing currents through the soil in which they are growing. From day to day they will be compared with untreated plants of the same age and kind. It has been discovered that when metallic plates have been sunk on either side of growing pea seeds, and when a current from a single cell has been passed from one plate to another, the electrified seed, although germinating or sprouting later than normal ones, will outstrip the latter at the end of 45 days.

If a coil of wire, partly stripped of its insulation or covering, be imbedded in the ground, and if mustard seed be planted along it, the sprouted seedlings near the uncovered part of the wire which allows the electricity to leak out, will, at the end of the week, be one-third larger than the seedlings growing along the covered portions of the wire allowing no electric leakage.

MEASURING SPEED OF PLANT GROWTH UNDER ELECTRICAL STIMULUS.

Beans were divided into equal lots by one experimenter, who planted each lot in a glass cylinder. One cylinder was set aside, its beans growing normally; but the others were electrified by currents passed through them each day. On the fourth day leaves commenced to appear on the electrified bean plants, but not on the normal ones. At the end of a week the stimulated plants had attained considerable size, but the unelectrified were barely commencing to show themselves above the soil. It has also been observed that plants thus stimulated are larger when grown near the positive electrode than when near the negative.

CHIEF WOODS, IN CHARGE OF ELECTRIC TESTS, AT WORK IN HIS LABORATORY IN THE PLANT INDUSTRY BUREAU, U. S. DEPARTMENT OF AGRICULTURE.

Some Russian Experiments

To troubled Russia, Mr. Ernst Bessey, a botanist of the Bureau of Plant Industry, lately journeyed to make some special studies in this interesting science. While at St. Petersburg, he heard strange tales of an inventor who claimed a secret process of increasing the yield of the sugar beet two and one-half times; and also of greatly hastening nature's production of cotton and grapes. This the inventor was alleged to accomplish by putting metallic plates into the ground, connecting them with wires reaching to a building to which visitors were denied entrance. Mr. Bessey looked into the story; found it to be based on fact; and hastened in search of the mysterious inventor.

A meeting with the magician of the metallic plates and wires was arranged in our consulate-general, St. Petersburg. Information was also obtained from the Czar's Ministry of Agriculture; and it was further discovered that this imperial department had just given the inventor a subsidy of 100,000 rubles ($77,000) with which to put his secret process into operation in the cotton fields of Turkestan.

It seemed unlikely that Russia would give such a large subsidy for the demonstration of a mere theory. Mr. Bessey looked about him for the proofs of the wild-sounding claims. He found that the inventor had bargained with certain rural Russians to have large tracts turned over to him. All that the inventor then asked was a guarantee that he should receive one-third of the excess profit realized from the treated ground. Thus obtaining the ground for his experi-

Greenhouse Laboratory of the Plant Industry Bureau, Department of Agriculture.

mental purposes, he first reserved a fraction whereon the crop was to grow normally and according to the usual methods of cultivation. This area was used as a "check field," and the yield determined the excess from the treated land. The latter he prepared for the tests by thrusting here and there into the soil electrodes connected by wire with a central electric station.

Fields of many acres, with uniform fertilization and cultural methods, were thus obtained by the inventor. According to Mr. Bessey's letter, recently received at the Bureau of Plant Industry and not yet made public, the untreated sugar beets in the "check fields" gave last season 19 per cent of sugar. The electrified beets gave 22 per cent, and were ready for harvesting some weeks earlier than those of the untreated fields. The electrically treated soil, furthermore, yielded apparently twice as great a weight of beets as was yielded by the normal fields. Thus, by doubling the weight of the beet and increasing the sugar contents of each beet electrically enlarged, about two and one-half times as much sugar was obtained from the electrified as from the normal soil, and in much shorter time. If this system is what it is alleged to be, the Bureau of Plant Industry will experiment with it in this country.

Electricity at Agricultural Experiment Stations

Prof. C. B. Warner of the Agricultural Experiment Station at Amherst, Mass., some years ago devised an experimental electric garden. Its soil was undermined at a depth of two inches with a con-

New Electrical Laboratory of Plant Industry Bureau

tinuous copper wire, which recrossed the plot at intervals of a few inches, and which was fed with a current by apparatus in a neighboring building. After supplying current of varying strength, it was found that many varieties of seeds sprouted much more rapidly, many plants blossomed much earlier, many of the roots and many of the tops of certain others were much larger, than in the normal garden adjacent.

In some of Mr. Woods's tests the air in which the plant is growing will be electrified. It has been discovered that when static electricity is discharged upon growing seedlings in a spray, so to speak, through a wire breaking up into fine points, there is an increase in growth.

At the Utah Agricultural Experiment Station, preliminary tests were made about 1894 to gather atmospheric electricity and stimulate vegetable growth therewith. A pole some twenty feet tall was topped with a long wire terminating in a metallic brush, the wire being connected with a metallic grating beneath a growing garden plot; and the experiment seemed to demonstrate that the electricity pervading the air even on clear days can be thus drained off sufficiently to stimulate the growth of certain vegetables.

Mr. Woods may cover a small part of a field with fine parallel wires about a yard apart and provided with metal points at intervals. This will be supplied with current during about eight hours each day for several months. Preliminary experiments with this method, made in France and Scandinavia by Lemstrom, a celebrated plant physiologist, showed that the yield of a barley field thus electrified was 35 per cent greater than that of an untreated field alongside. The quality of grain, moreover, was better. Favorable results were also obtained with the same apparatus applied to malt.

A CORNER IN ONE OF THE LABORATORIES OF THE PLANT INDUSTRY BUREAU.

No experiments in electroculture had heretofore been made by any bureau of the Department of Agriculture. So-called "electroculture," consisting in the forcing of plants under electric light applied during the night as a substitute for daylight—which really amounts to the working of plants "overtime"—has been

attempted with success by some of the agricultural experiment stations throughout the country, the results attracting considerable attention.

Professor Corbett, of the Bureau of Plant Industry, who undertook part of this electric light forcing, gives the following statement of the results:

"Plants grown under the light from a 2,000-candle-power arc lamp at night, in addition to the influence of the sun's rays during the day, performed queer antics. They seemed to catch the spirit of the times for fast living; and, instead of growing along in the good old way, developing an extensive root system and many leaves, they began at once to prepare for seed time."

Life

WE live in deeds, not years;
In thoughts, not breaths;
In feelings, not in figures
on a dial.
We should count time by heart-throbs.
He most lives who thinks the most,
feels the noblest, acts the best.

—PHILIP JAMES BAILEY.

U. S. Naval Proving Ground at Indian Head

Describing the Severe Tests to which Ordnance, Projectiles, and Armor-Plate are Subjected

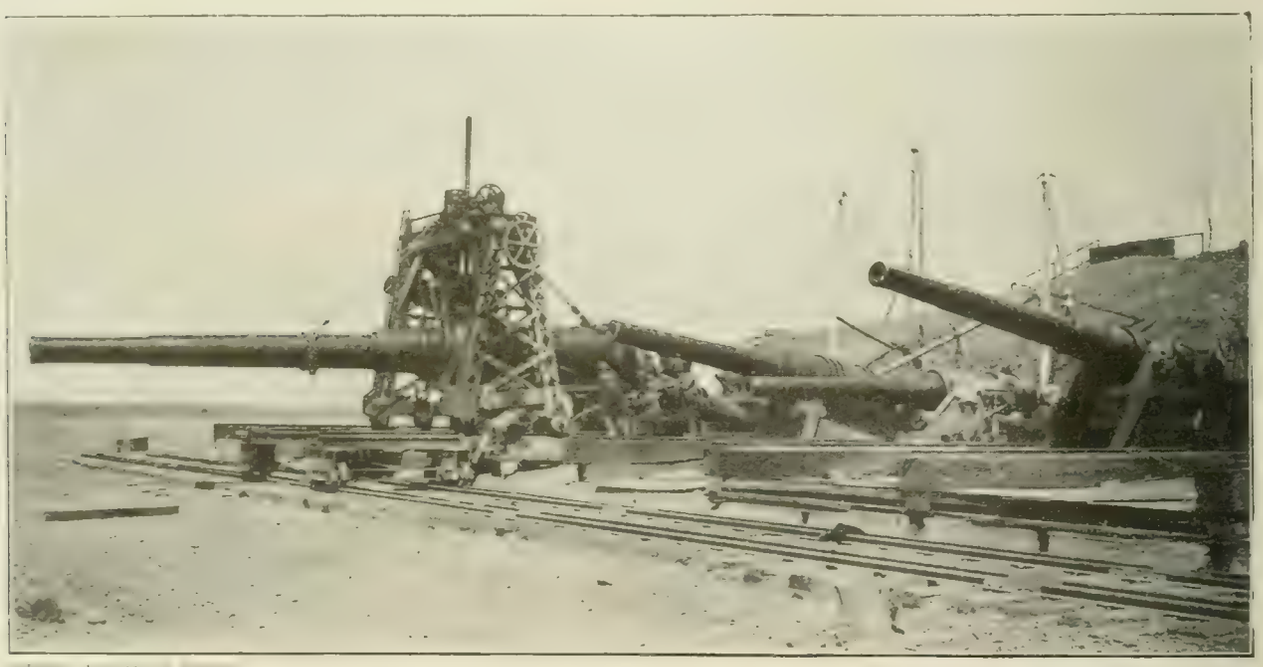
By ROBERT G. SKERRETT

Formerly of the Navy Department, Washington, D. C.

THE nearest peace-time approach to actual warfare is the work of the Naval Proving Ground at Indian Head, Maryland, in its multiple duty of testing all that pertains to the defensive and the offensive ordnance equipments of our modern men-of-war. There it is that our guns, great and small, speak in the harsh voice of conflict; and there it is that the projectiles that are to break down the sheltering bulwarks of an enemy are sent against samples of the very armor that is to guard the "vitals" of our own fighting craft. As near as possible, the conditions of war are simulated, that the resultant data may reliably foretell the probabilities of the day of strife; and one hour spent at Indian Head will tell more of the might of modern guns and the resisting power of the best of case-hardened armor, than whole books of statistics and the material presence of the greatest of our ships themselves.

In 1890, the Naval Proving Ground was transferred from Annapolis, Maryland, to its present site at Indian Head—twenty-five miles down the Potomac River, below Washington—in order that the place of proof might be conveniently near the Naval Gun Factory, and materials conveniently located for easy transport by water. The wisdom of the change has been amply proved, and, the site being within easy reach of Congress, has afforded a beneficial object-lesson to our national legislators.

In the ordnance equipment of our men-of-war, nothing is taken for granted, and everything that contributes to that phase of our fighting craft is carefully proved before it becomes a working part of our guardians of the peace. The wisdom of this has been established beyond question; and the few accidents we have had in our service have arisen from circumstances that even the Proving Ground could not presage. Experimental



RANGE BATTERY AT U. S. PROVING GROUND, INDIAN HEAD, MARYLAND.
The guns that tell the story.

work of a varied nature is also carried out at the Proving Ground and, in advance of changes in any direction, new devices of all sorts are exhaustively tested before being accepted as fit for the service.

Proving the Guns

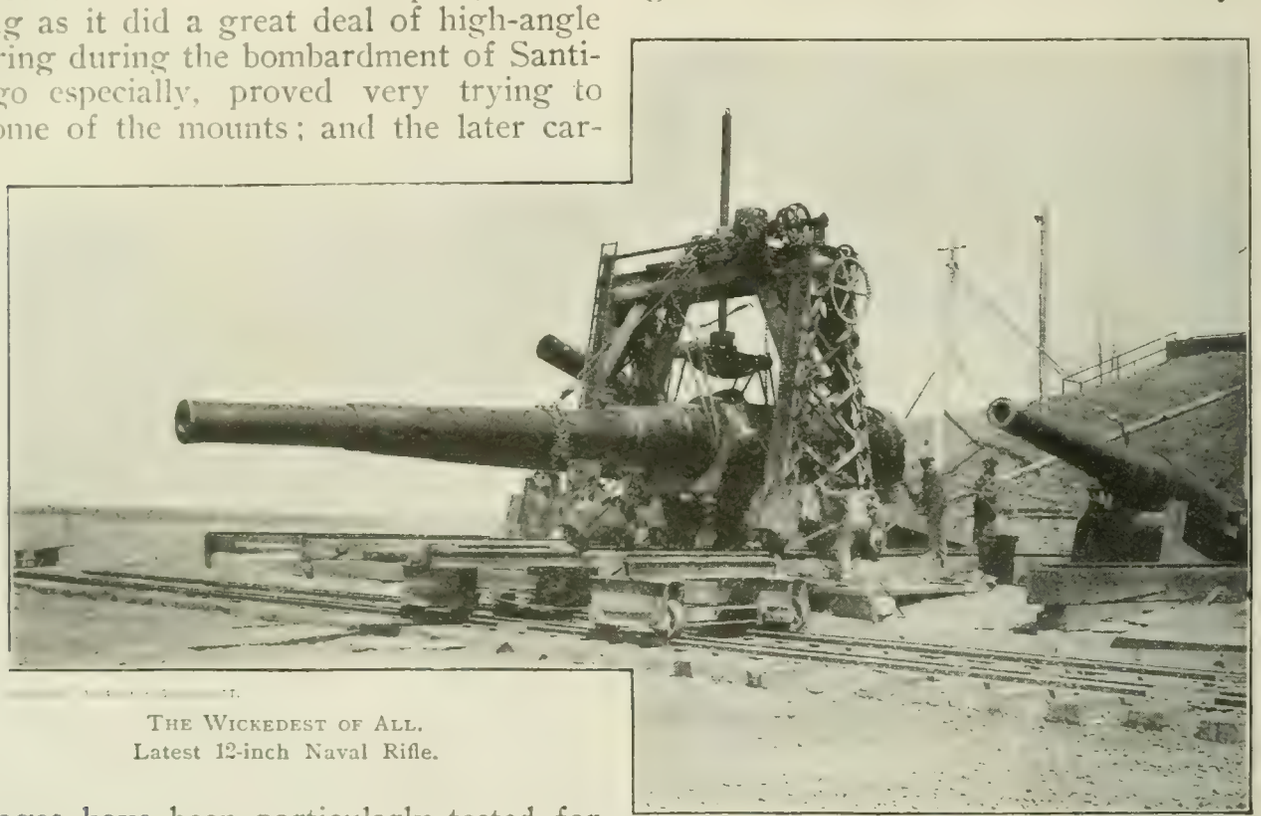
Fine and wonderfully fabricated as are the guns turned out by the Naval Gun Factory—they have no superiors the world over—they are not permitted to

DISCHARGE OF AN 8-INCH RIFLE.

ride their places among the armaments of our fighting ships until after they have been tested at the Proving Ground. Each gun, large and small, as it is completed, is shipped to Indian Head, and fired five times, with progressive charges, until the final chamber pressure is one and a-quarter times that required in service. The maximum service pressure is, for big guns, about sixteen tons to the square inch; and the maximum test, or proving pressure, will be quite twenty tons. The velocities are correspondingly high, so that an accurate test may be had of the ability of the muzzles to withstand safely the service tax. With the adoption of smokeless powder as a propellant for our naval guns it was found that the high chamber pressures were naturally carried well along toward the muzzle; and during Rear-Admiral O'Neil's regime all of our big, high-powered weapons were jacketed throughout the chase to the very muzzle. The wisdom of this was exemplified by the accident to one of the *Iowa's* old-pattern, 12-inch guns, the muzzle of which was blown off during target practice last year. This gun has since been repaired and strengthened, and is now installed at Indian Head, and will be used in solving some of the problems connected with its untimely retirement from active service afloat. After a gun has been proved, it is stamped with a large letter "P" and the initials of the officer in charge of the Proving Ground, and is then carried back to the Naval Gun Factory for final adjustment and its service fittings. Where the private manufactories building guns for the Navy have their own proving grounds, such guns

are proved there, the proof being conducted by the naval inspector of ordnance stationed there; and where the works are not so equipped, the guns are sent to Indian Head.

The proving of a gun also involves the proving of the mount or carriage upon which it may have to rest later. To test the latter effectually, not only must the gun be tested at its maximum proof pressure but the weapon must be elevated so that the maximum of stress may be brought to bear upon the recoil mechanism. Our war with Spain, involving as it did a great deal of high-angle firing during the bombardment of Santiago especially, proved very trying to some of the mounts; and the later carriages have been particularly tested for this kind of work.



THE WICKEDEST OF ALL.
Latest 12-inch Naval Rifle.

Testing the Powder

Hand in hand with the proof of a gun, when it is possible, goes the proof of powder, projectile, and armor. Powder is known in the service by its "index." An "index" of powder is a blended mass of the propellant ranging in weight from 25,000 to 30,000 pounds. After such a mass of "index" is boxed and ready for shipment, a sample of it—its amount being proportional to the caliber of the guns for which it is intended—is sent to the Proving Ground for proof. Should the proving show the powder to be stable and the development of pressures normal, the rest of the "index" is issued to the service. Sometimes this particular blend or "index" may prove to be a little quicker than that previously issued. If this be the case, then the charge must be reduced, or the powder issued for guns of a caliber suited to this quicker-acting propellant. Should the powder, on the other hand, prove slow, then it may need further drying; and, before issue to the service, it is sent back to the factory for treatment, and is subsequently proved again. A most accurate record is kept of every lot of powder tested.

One phase of the proof of the powder is determining the range of the firing gun. To make this a matter of nicety of measurement, the powder charge is carefully determined only a short while before the range-firing is begun—the object being to offset any change in velocity due to modification of the powder through drying, etc. This work is done by laying the gun at an exact angle of elevation of one degree, and training it upon a fixed mark before firing. The fall of the shot is measured by instruments. This operation is repeated at each of the odd degrees up to 15, and then back again through the same angles. The wind and other atmospheric conditions are carefully noted; and, after these deductions, a range-table is plotted for the particular caliber of gun in question.

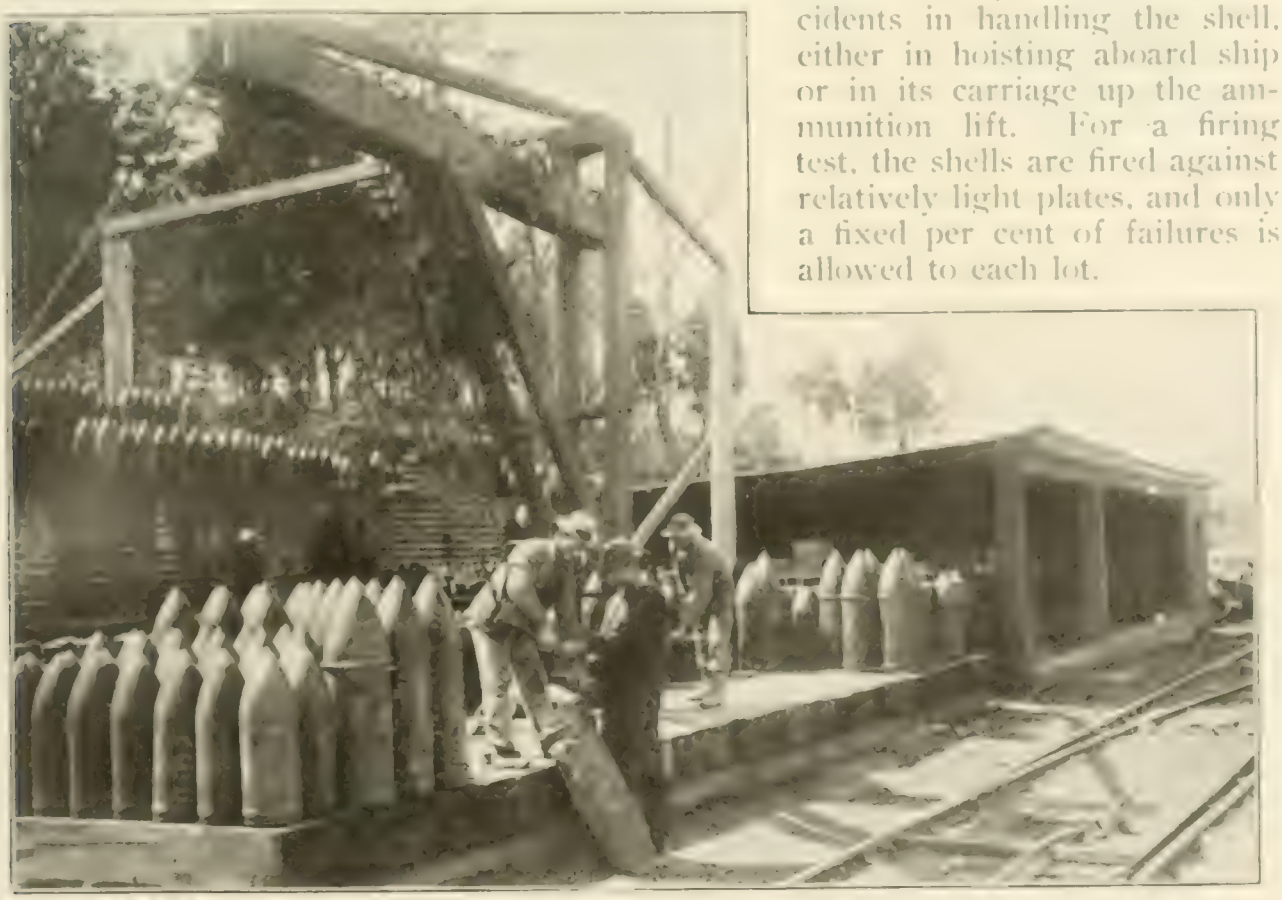
Armor-Plate

The Navy is now supplied with two

kinds of shell—armor-piercing and common; and all of the shells are most carefully proved before a given lot is accepted from the manufacturer and issued to the ships of the service. From each lot manufactured, one shell is selected by the local naval inspector of ordnance, and shipped to Indian Head. If the shell is an armor-piercing projectile, and of 3-inch caliber or upward, it is capped, and is fired at an armor-plate of a thickness corresponding to the caliber of the particular shell. If it perforates the plate—no fragment remaining in front—from a distance of about 100 yards, and at a velocity fixed by the Bureau of Ordnance, the lot it represents is accepted; otherwise, not. Common shells are fired at nickel-steel plates of half their caliber in thickness, and with just velocity enough to get through; and they must come out on the other side without sustaining any fracture that would open up the shell cavity in which, in time of war, is the explosive charge. Following this test, the shell is loaded with fine-grained black powder, and exploded in a suitable chamber or bomb-proof. If the fragmentation is satisfactory, the lot is accepted from the manufacturer. Upon the naval inspector at the steel works rests the responsibility of the shell being substantially typical of the particular lot.

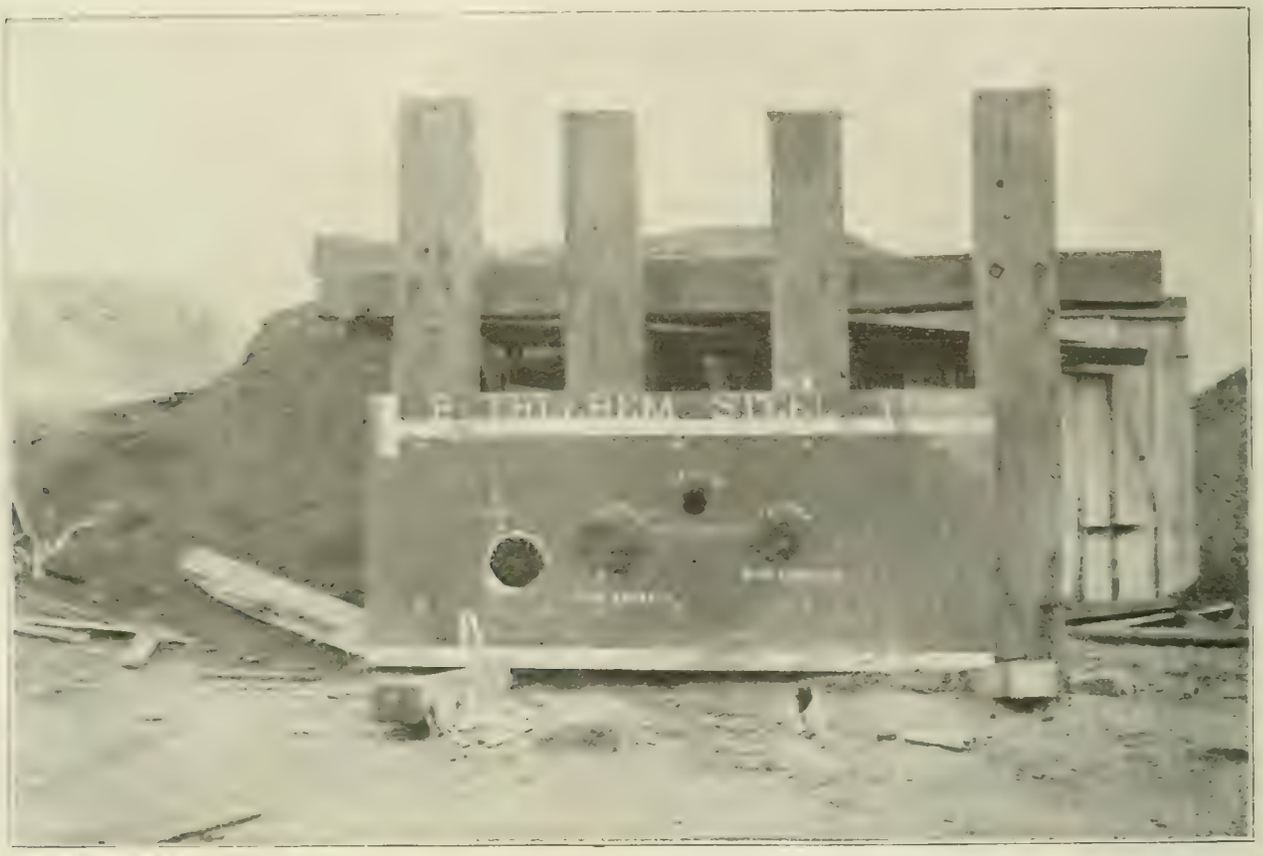
The ammunition for all guns of 6-inch caliber and under, is "fixed"—that is, the powder and projectile are put up in cartridges; and to insure the soundness of the cartridge cases, one out of every lot of a hundred is proved by being fired six times at service pressure, after which it must be still in perfect condition. No deformation is permitted; and after each and every discharge it must be easy of entry into and extraction from the breech of the gun. This soundness of the cartridge case bears directly upon the prime question of rapidity of fire, and it is vital that there should be no risk of one jamming at a critical moment in the hour of action.

In connection with the explosive shell, the fuses that detonate them are also proved. The proof of a fuse consists in dropping the fuse, in an unloaded shell, from a height of thirty feet, without deforming the mechanism so as to expose the detonating plunger. The object of this test to guard against accidents in handling the shell, either in hoisting aboard ship or in its carriage up the ammunition lift. For a firing test, the shells are fired against relatively light plates, and only a fixed per cent of failures is allowed to each lot.



SHELLS OF VARIOUS CALIBERS FOR TEST.

Nothing, perhaps, is more suggestive of the might of modern ordnance than the results of its attack against the hardest of carefully treated armor. Then it is that we realize that every thing in nature, even these heavy walls of cold and seemingly unyielding steel, is more or less plastic. A 12-inch shell, with its armor-piercing cap, at a distance of a thousand yards, is able to go *undeformed* through 23 inches of the best Krupp armor. To do that, however, it must have an initial velocity of 2,800 feet per second. The mind cannot grasp the significance of these figures, in the abstract, and the object-lesson itself leaves only an astounding sense of wonder.



A SUCCESSFUL KRUPP PLATE AFTER ATTACK.

Lieutenant Joseph Strauss, U. S. N., at one time in charge of the work at Indian Head, tells us:

"Face-hardened armor is tested by firing armor-piercing projectiles against it with normal impact—that is, at right angles to the face of the plate. The plate is always backed with 12 inches of oak backing secured to two 5/8" skin plates by armor bolts spaced at normal intervals. It is set up against the target structure at a distance of about 100 yards from the gun. The velocity of impact and the caliber of shell are fixed with reference to the state of the art of armor manufacture, and the plate must be able to resist a given number of blows without developing *through* cracks or permitting any shot to penetrate through the skin plates."

Sample plates from every lot of armor are selected by the naval inspector at the armor factory; and, before the lot is passed, the sample must withstand the attack prescribed by the Bureau of Ordnance. Failure on the part of the test plate is not always accepted amicably by the manufacturers; but the final decision is generally made with strict regard to the Government's interests and what that may mean in the hour of conflict.

Velocities of Projectiles

The velocities are measured by firing shot through two electrically connected wire screens, called "velocity screens." The shot, as it passes through the first screen, cuts some of the wires, which, breaking a circuit, causes a big weight to drop in the chronograph. In passing through the second screen, the shot repeats the operation, and releases a second and smaller weight that causes a knife-edge to strike the still falling large weight. This knife-edge makes a mark on the big weight, which, when measured

from one end of the weight to that point gives the velocity of the shot in fractions of a second.

The pressures in the guns are recorded by small steel gauges placed in the breech of the gun after the last part of the powder charge has been rammed home. These gauges contain a piston or plunger of steel directly open to the pressure of the gases in the chamber; and underlying the piston and within the body of the gauge is a disc of copper which has been previously compressed to its present thickness by a known pressure. After discharge, these copper discs are carefully measured by fine micrometer gauges, which give a direct reading in pressures, corresponding to the further compression of the discs by the pressure of the exploding powder.

This work at Indian Head is not without its elements of risk and danger; but, because of the many precautions taken, there have been very few accidents, and the record is one that stands a monument to the intelligent zeal of the men who have successively administered the station. Every day in the year, excepting Sundays and holidays, the Proving Ground is a busy place, and the patient, painstaking work will tell its own story best when our guns are forced to speak again as they have but once before in passing the exacting examination at Indian Head. If then they make for themselves the marks that won them a right to their permanent emplacement, we shall have ample reason for pride in the equipment of our most efficient peacemakers.

Youth's Agitations

WHEN I shall be divorced, some tell you,
From this poor present self which I am now;
When youth has done its tedious vain expense
Of passions that forever ebb and flow;

Shall I not joy youth's heats are left behind,
And breathe more happy in an even clime?
Ah, no! for then I shall begin to find
A thousand virtues in this hated time;

Then I shall wish its agitations back,
And all its thwarting currents of desire;
Then I shall praise the heat which then I lack,
And call this hurrying fever generous fire;

And sigh that one thing only has been lent
To youth and age in common—discontent.

—Matthew Arnold.

SHED IN WHICH THE *ROOSEVELT* WAS BUILT.
View taken across the river from Bucksport.

The Far North Again

Construction of the Strongest and Most Powerful Ice-Breaking Ship Ever Built—Plans of Commander Peary's Next North Polar Exploring Expedition

By WINTHROP PACKARD

THE strongest craft ever built in a shipyard was launched March 23, at the shipbuilding plant of McKay & Dix, near Bucksport, Me. The mission of the ship is as unique as its build. It has been constructed solely for the purpose of carrying Commander Peary, the dean of arctic explorers, to the uttermost limits of navigation in the far north, whence with dog sledges and Eskimos he will make one more dash for that point which is the dream of all arctic explorers—the north pole.

Surely, if any man is fitted by physique, mental equipment, and experience, to succeed in this hazardous undertaking, it is this noted explorer, who will next June start on his eighth trip to the arctic regions. To appreciate this, one has but to see him, as did the writer, in the little shipyard near the ice-bound river, where he watches with careful eye the growth of his new craft; and to talk with him of his plans for the new expedition. The man has a striking build and carriage—lean, sinewy, erect, over six feet of forceful physique, carrying within its splendid proportions an indomitable energy. Such is the explorer himself; and his ship is to be as strong to attack, as lithe to escape, and as capable of withstanding the buffetings of the arctic ice and storms as he.

Peary Outlines His Plan

"The first requisite for an attempt to reach the pole," says the explorer, "is the right kind of a ship. More than once I have been so near the goal that could I and my dogs have been fresh, instead of already exhausted and worn with travel over the ice, we could have made the trip. If I could start on the ice journey from Hecla, the chosen point on the northernmost part of Grant Land, I should have a distance of but 420 miles to traverse to reach the point where latitude ceases and all directions are south. More than once I have made an equal distance with dogs and sledges, but never have I started from such a vantage point. I believe that this coming summer it will

be possible for me to reach Heela with the new vessel which I am now building. My plan is to establish a permanent base or substation at Sabine, a point easily accessible every summer; then, passing northward from this place, to establish caches all along from Sabine north. With the new boat we shall force our way through the ice to a safe anchorage near Heela and go into winter quarters there. Meanwhile I shall have redistributed the whole tribe of Whale Sound Eskimos along the coast at needed points, with the vanguard of the strongest and most intelligent with me at Heela. Long and pleasant intercourse with this tribe has devoted it to me and my work, and I can count on its loyal and intelligent cooperation. The advance from Heela northward will come with the first returning light of February; and if all goes well to this point, I am confident of success.

Work for the New Boat

"The weak trouble of my seven previous expeditions has been the ship. If she had the structural strength to withstand the crush of the ice, she did not have the power to force herself through it. The *Charles H. Darling* (christened the *Roosevelt* at its launching) will combine both these advantages. She is not very large—181 feet over all, 34 feet beam, with a mean draft of 16 feet and a displacement of 700 tons; but she will be the strongest built ice-breaker in the world, stronger than the Norwegian *Fram* of [illegible] tons. She is not only so planned as to resist to the uttermost all ice pressure, but [illegible] is different from all other vessels. Below the water line she is so shaped that any extraordinary ice pressure will lift her, and she will slip away from danger. Best of all will be her powerful engines. She is hardly larger than a big tug, but she will have the power of a liner. No

[illegible]

ocean-going tug which runs out of New York harbor will have the strength to thrust and pull that she is to have. The crucial part of the trip will be the traverse of what may be called the middle division of the route—the ice-encumbered channel between Cape Sabine and the north coast at Cape Heela. Yet the distance is only 350 miles, and has been accomplished by four exploring vessels already, one of which, the little *Fram*, by some extraordinary good fortune, made the run without even seeing ice. The route is, however, more than likely to be packed with heavy floes, through which only so powerful a vessel could turn and twist and thrust its way unharmed. Other explorations of the ice-ridden seas have been conducted in vessels strong enough to withstand ice pressure, but none have had the proper ice-leaving power. They

Model of Commander Peary's New Arctic Explorer "Roosevelt"
A 3-masted, fore-and-aft, schooner-rigged steamship, with auxiliary sail power

have been sailing vessels with auxiliary steam power. The new ship is to have sails, to be sure; but they, and not the steam, are to be auxiliary."

Penobscot Captains Approve Her

Never before on the Penobscot River, nursery of hardy sea-captains and home of shipbuilders as it is, was built such a ship, and the little shipyard is a mecca for pilgrims from up and down river. They are canny in shipping matters, these old captains and shipwrights; they know the full value of every extra beam and every extra reënforcement of strength and stability, and they wagged their gray beards in approval as the little vessel took shape. The shipyard as well as the ship is an anomaly to them, for never before in a Maine shipyard was a ship all comfortably housed in a shed for winter shipbuilding. As the explorer says, she is not a large vessel, but her structural get-up is nevertheless impressive in its massiveness. Keel, keelson, stem, and sternpost are of solid white oak timber, well seasoned, from the Virginia forests. The frames are of white oak also, made triple, three curving ribs bolted together where ordinarily but one is used. Immediately over these frames are laid diagonal straps of steel running from stem to stern on either side, making a lattice lacing of rectangular openings from one end to the other. Over these straps again are laid a double course of five-inch planking, the inner of yellow Georgia pine, the outer of white oak; and between the two will be a sheathing of tarred hemp. The outer course, after it has been most carefully calked, will be overlaid with extra heavy sheet copper. Inside, the frames will be covered with three-inch yellow pine "ceiling," and the utmost caution will be taken to make everything absolutely water-tight, warm, and weatherproof.

COMMANDER PEARY AND PARTY STANDING ON KEEL OF NEW ARCTIC EXPLORER.
View taken in McKay & Dix shipyard, Bucksport, Me.—Commander Peary stands 2d from left; Captain Houghton, Superintendent of Yard, 4th from left; and Captain Dix, builder, 1st on right.

Massive Structure

The deck beams are of yellow pine of exceptional stoutness, the ones forming the main deck being spaced four feet apart from center to center. These, as

well as those of the lower deck, placed directly beneath them, are all anchored and tied by throughbolts riveted up inside. Such massiveness of structure is in itself double and triple that given any ordinary vessel, but these are only the beginnings of its structural strength. Half-beams of deck beams are braced from the center to the sides by diagonal timbers of heavy yellow pine, so arranged as to take all the pressure from the sides of the ship "end on," and would seem to be enough to defy any crushing force that can be brought against them. To give greater vertical stiffness, each beam will be supported by tie-rod stanchions of steel and wrought-iron piping, so arranged that they may be set up from time to time during construction, to provide against any sag developing in building and to secure perfectly rigid support.

Clever Design of Hull

Thus the sides, bilges, and bottom would seem to be so built, safeguarded, and reenforced as to stand even the fiercest pressure of the arctic floes if it should be directed rigidly against them. But the cunning of the designer has gone farther than this. Just as a wedge, pressed between opposing forces, slips from between them and escapes, so will

Master-Builder Nel[illegible] and Outstanding Section of 8-Ton Sternpost.

the new ship, when nipped between the floes, simply rise above them and escape their crushing force. Most ships are built more or less "kettle-bottomed." That is, their sides drop nearly perpendicularly, and swing in rather abruptly toward the keel when the required depth is obtained. The shape of the Peary vessel is a slippery oval which the floes can no more grasp and hold than the thumb and finger could the greased small end of an egg.

"My, but she'll roll in a heavy sea!" say the wise old ship-captains, viewing this innovation in shape with the critical eye of long experience. Perhaps she will; but that matters little if she slips coldlike from the grasp of the northern ice in the time of danger.

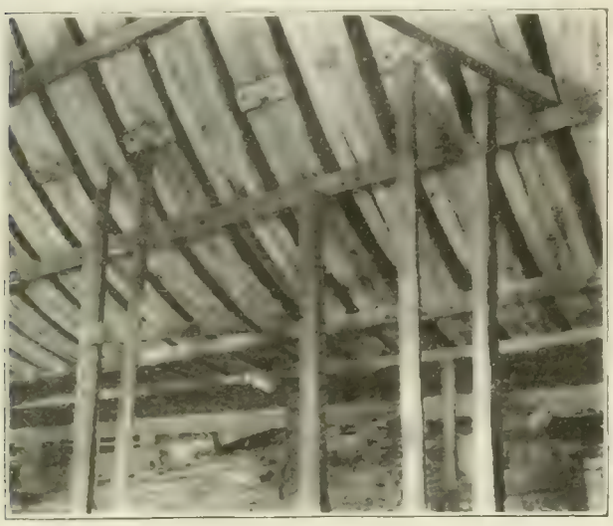
Other Reenforcements

Even in great strength and slippery shape the precautions against the nipping ice do not end. A heavy white oak guard rail, eight inches by twenty, is worked abreast the plank-shear from stem to stern, and so securely fastened to stem-frames, plank-shear, and waterway, that it will be strong enough to support the entire weight of the loaded ship. On the face and under side, this guard strake will be protected by a heavy angle-bar of steel. Its purpose will be twofold—first, to add greatly to the longitudinal strength of the ship; second, to help the floes lift the ship out of water when they press against the oval sides and crumple and press upward as the ship is crowded by the ice. It will form a fulcrum for the ice levers; or, if this fails, the ship's

company can place jacks on the solid ice beneath it and lift on this guard rail, lifting the ship out of danger till the pressure of the floe is relieved.

An Armored Craft

To take the worst of the rub of the passing ice, the bow, stern, and water



UNDER-PART AMIDSHIP.
The three-fold timber construction shows strength of steamer—the strongest hull ever built.

line will be armored. At the bow, one-inch steel plating will be worked from the keel upward to three feet above the load water line and three feet aft. At the stern, plating of similar thickness will extend fourteen feet forward. At the water line, the plating will be five feet wide, five-eighths of an inch in thickness, and will extend from one foot above the load water line to four feet below.

There will be two deck houses. The forward one will be big enough comfortably to house Commander Peary, the scientific staff, and the ship's officers; and in this they will live on their journey to the far harbor on the northerly shore of Grant Land. This deck house is portable; and when the ship reaches the desired base, it will be taken ashore and set up to form headquarters for the staff on the ice-bound coast at Hecla.

Very Powerful Engines

So much for strength and resisting power. Surely a ship of such strength and so cunningly designed to elude the crush of ice, was never built before. But after all, this is but a summing up of her negative virtues. It is in her kinetic force that her chief value will lie, for, with all her strength to resist floe pressure and grinding ice, her motive power is of more importance. She is to be a very powerful steamship; and while she has sails, they are merely auxiliary or for emergency use. The motive power will be a single inverted compound engine, driving a single ten-foot screw, the steam being supplied by two water-tube boilers. Under forced draft this engine should develop 1,400 horse-power; under merely natural draft, 1,200. The bunker capacity is 700 tons of coal, and she will carry also a deck load of 150 tons in bags.

Such is the ship that has just been launched at the little shipyard. Her sail plan is that of a schooner yacht, her bowsprit being but a stub, her masts short, carrying no gaff topsails, but spreading two big staysails in their stead. Commander Peary knows every timber that is put into her, watches with careful eye the setting up of every bolt, and takes equal pride with the builders in making the unique craft perfect in every part. The same might well be said of every man that works on her; and when she goes forth to fight the arctic ice, she will be as complete as ship-designing wisdom, shipbuilding skill, and loving care can make her.

STEM OF PEARY ARCTIC EXPLORER "ROOSEVELT."
View showing timber construction designed to resist ice pressure and exert lifting power.

Some Amusing Incidents

But it is not only designers, builders, and workmen who take a vivid personal interest in the new ship. She has been the talk of the neighborhood, and the throngs who came daily to see her grow would well have carried her off piecemeal if she were not too strongly put together and built of too tenacious material to be thus demolished. Few are the chips that are left in the shipyard, and guaranteed blocks from the keel would have a ready money value if they were to be found on the market. All such have been eagerly carried away as treasured souvenirs. There is no doubt that in a year there will be enough genuine bits of wood from the keel of Peary's wonderful ship exhibited to build at least one new vessel entire. One man is planning to have a booth at the Maine State Fair, near Bangor, where carved articles made from these blocks will be for sale.

The head of a near-by educational establishment has a wiser scheme than this, however. He has had a photograph taken of the model over in the shipyard office. He is having made as extensive a collection as possible of genuine blocks from the ship's timbers—waste blocks, of course. From this photograph a steel die is being made; and in each block, with this die, will be burned deep a representation of the new ship. Then letters will be sent to the alumni of the institution, soliciting donations to the school fund, and offering in return one of these unique blocks with a receipt for the money.

The probable cost of the new ship is $75,000; and she will be worth it, not only to the cause of arctic exploration, but to the furthering of general business and the promotion of the cause of education in the good old Pine Tree State.

The Passing Show

ALL things that pass
Are wisdom's looking-glass,
Being full of hope and fear, and still
Brimful of good or ill
According to our work and will.

FIG. 1. MOORE ELECTRIC LIGHT AT 1381 BROADWAY, NEW YORK CITY.
The tube here shown is 155 feet long.

Moore Electric Light

The Evolution and Recent Development of the Vacuum-Tube System of Electric Lighting—Some Details of its Installation and Operation

By RUSSELL FAY TRIMBLE

IN our large cities the tendency to turn night into day is rapidly increasing. Places of amusement, restaurants, business houses, and banks keeping open 24 hours a day, prove beyond a doubt that the lighting facilities of the future will have to be such that it will make no difference whether the sun shines or not; that is, we shall have to use "artificial daylight." Realizing this, Mr. D. McFarlan Moore, over ten years ago started to make an electric "artificial daylight," which is now a practical success.

The subject of vacuum-tube lighting is one that has long engaged the attention of the scientific world. A few years ago this method of illumination was but a dream of the most daring; now it is actually a commercial commodity; and, owing to some of the recent developments in this system of lighting, it is rapidly becoming a competitor of the arc light and the incandescent electric lamp. The most familiar form of light is the incandescent electric lamp, an invention of but a quarter of a century ago; yet in less than another quarter of a century vacuum-tube lighting promises to be the most familiar, for it is the only light that closely imitates daylight in color and diffusion. It is a white light emanating from the entire length of a long glass tube, which appears as though it were entirely filled with a densely white, light-giving smoke, but which in reality is due to electricity passing through a special gas which fills the tube.

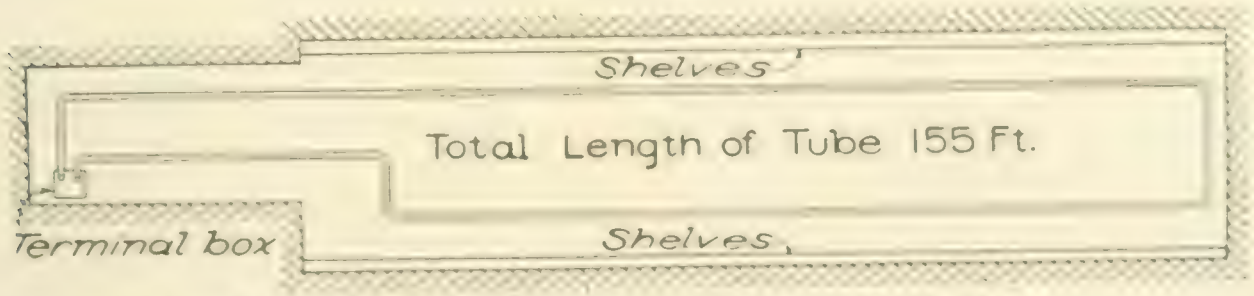
The Evolution of the System

The first electric light ever made was a vacuum-tube light. In 1675 an old

French monk named Picard, who dabbled in physics, noticed while handling a mercury barometer that the friction of the mercury in the bulb suffused it with a faint glow of light. Thirty years later one Hauksbee took a glass bulb, held his hand against it while it was revolving rapidly, and noticed that there was a faint light within it. There was a long line of experimenters down to the time of Geissler, but only meager results were obtained until Geissler made the first tubes that were at all successful; but even they were very crude and small, and have never been of any value except as laboratory wonders. Mr. Moore is the pioneer in commercial vacuum-tube lighting, and he has produced results of great importance in this field. Almost every year the Moore system of lighting has changed radically; but two constant factors have always remained, namely, the glass tube and the electricity flowing through a gaseous conductor. Although the system started with tubes only a few inches in length, some of the installations described in this article have tubes 155 feet long.

The necessary apparatus to cause the electricity to flow through the tubes has changed as radically as the tube itself. At first, special and delicate vibrating, or rotating, apparatus was necessary in conjunction with the source of the supply of electricity; but now no moving apparatus whatever is required, since the tubes are connected to a static transformer, receiving its energy directly from the street mains. The special gas in the tube through which the current flows is one of the most important factors in connection with this whole system, because at first no gas could be found which would produce light continuously for more than a few minutes; whereas the gas now in use seems to last almost indefinitely. Many metallic gases were tried, but on account of [illegible] (for example, color—it had been possible to obtain any purely metallic vapour, sodium which in all its properties could be used to approximate closely the desired qualities of daylight), and accordingly a newly discovered non-metallic gas—the exact nature of which is kept a secret—is now being used.

It has been maintained that there is no good reason why a light could not be made that would be as efficient as an electric motor. The motor gives an efficiency of 98 per cent; that is, for every 100 units of electric energy put into an electric motor, 98 of them can be utilized as mechanical power, while an incandescent lamp converts only 2 such units into light and 98 of them into heat, which is not desired, for a lamp is a device designed to give light, not heat. Few realize what a tremendous loss of energy this is. The difficulties met with in developing and perfecting this new system were enormous, necessitating, besides the principal basic conception, hundreds of other important inventions, extending from a new form of glass-blowers' fires to the electro-chemical intricacies involved in discovering a suitable gaseous conductor for the tubes, none of the many gases found in nature giving practical results.



[illegible]

Quality of the Light

All will agree that diffused daylight is the only perfect light; and its bluish-white tint has been the goal toward which all artificial light experimenters have striven, but which, until recently, none had attained. The problem of color is one of the principal factors in all kinds of illumination; but that difficulty has now been overcome, for the light from the

Moore vacuum tube is that soft bluish-white light that heretofore had never been attained in an artificial light. The proof of this is the fact that colors can be perfectly matched under its soft rays; and one of the leading art houses of New York has its artists mix their colors under this light. The nearer in quality any artificial light approaches natural light, the easier it is on the eye, and *vice versâ*—the further the color digresses from that of daylight, the more injurious it is to the human eye.

The radiation from all artificial lights so far has been wrong, from both the practical and the theoretical standpoints. It stands to reason that, to imitate daylight, radiation from a small spot is not correct. The radiation of light must be from a large area if we want to obtain light that will imitate daylight in diffusion, and this is a factor that has been entirely overlooked in the manufacture of all lights up to the present time. What is wanted is light, not lights; this can be readily seen by walking down any business street at night, where you will notice in the stores, in the windows, and on the signs hanging outside, long rows of incandescent lamps, long series of "spots" of light—from which the natural evolution is one long tube to take their place. Few persons realize how little need there really is for "units" of light, such as have been in use since the world began; because when light is as cheap as it undoubtedly will be, according to present indications, the time is not far distant when it will be considered an indication of poverty to use a "unit" of light. It is already a fact that the larger the business, the more general the illumination must be, and the fewer the spots of light. Why should electric lights be in units when 75 per cent of all that are in commercial use are not used as "units" at all, but simply as integral parts of a row or line of light? This is one of the reasons why the vacuum-tube light promises to be the light of the near future. Its radiation is not from a small spot, but from the entire surface of a long tube.

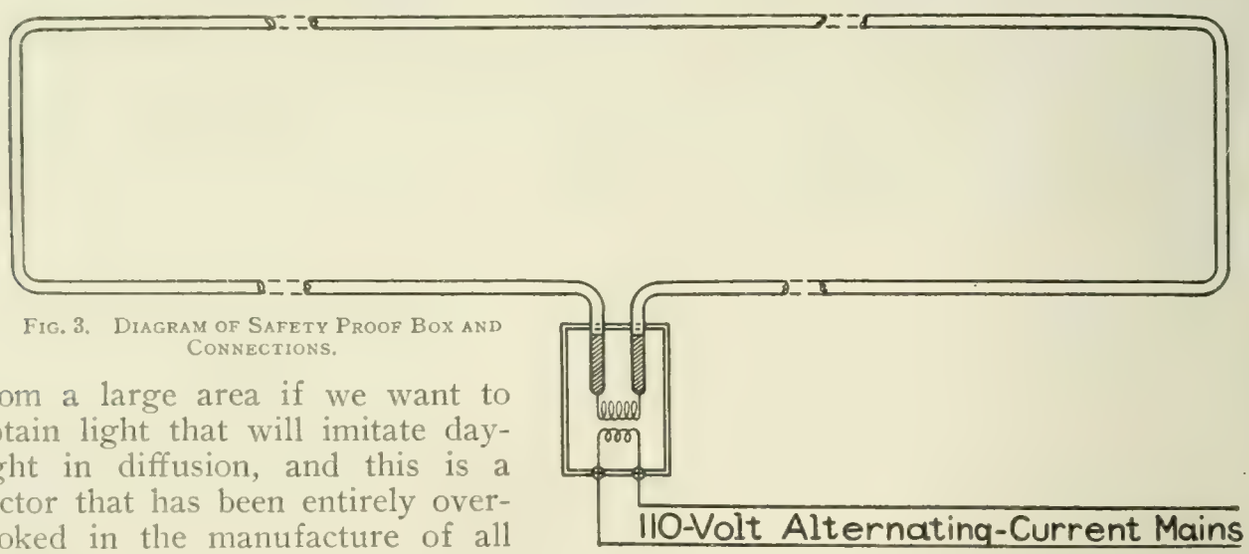


FIG. 3. DIAGRAM OF SAFETY PROOF BOX AND CONNECTIONS.

Typical Installations

Fig. 2 shows a diagram of a Moore tube as installed in a Newark, N. J., store. It was built in position as a permanent fixture, and has a radiating area that extends the entire distance around the store, which makes the diffusion perfect. This is proved by the fact that a person cannot get in a shadow. This store being comparatively narrow, the tube does not need to be run at a very high brilliancy, three to three and one-half candle-power to the foot being quite sufficient to give the desired daylight effect. In Fig. 1, the tube is the same length; but the office being considerably wider than the store, the light is run at six to seven candle-power per foot, the brilliancy depending upon the watts consumed, which average at present about 2.6 watts per candle-power.

Life of the Tubes

Life is another very important factor in an artificial light. The incandescent lamp has a total useful life of about 400 hours, after which time the light has grown so poor, and the efficiency so low, that it pays to throw away the bulb and buy another rather than waste current on a worn-out lamp. But the Moore vacuum tubes have already run 2,000 hours

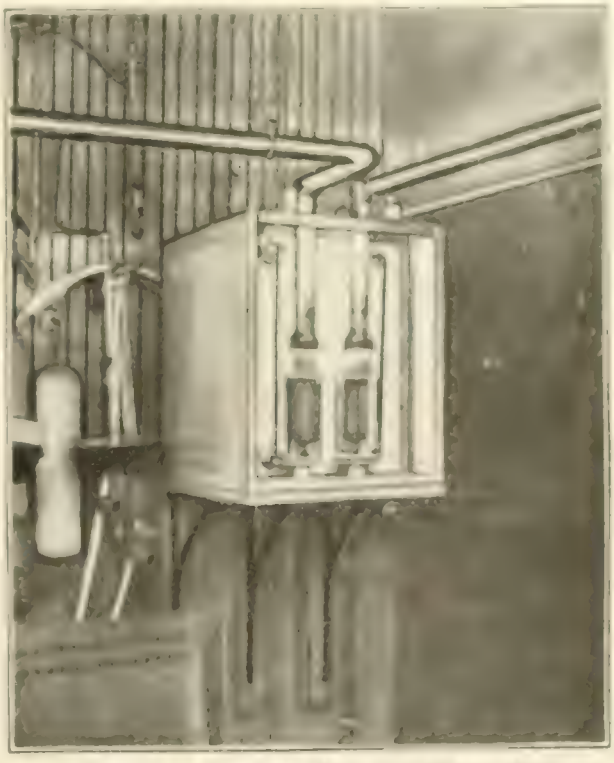
and are still in commercial use without any change in efficiency, as proved by accurate photometric and electrical measurements. How much longer they will run is still a very interesting enigma; but the present record is most certainly a wonderful step in the direction of unlimited life for a light. And another advantage is, that when they do burn out it is not necessary to throw away the glass tube, but simply to furnish it with another charge of gas, which will give it a lease of life for another 2,000 hours or more. This is a remarkable statement, since previous to the very important discovery of how to make a suitable gaseous conductor, it was impossible to construct vacuum tubes giving a similar light, so that they would hold their power consumption and light absolutely constant even for a few moments; and the fading away of their entire luminosity was but a matter of a very few minutes.

Cost of Operation

From the strictly commercial standpoint the most important thing in connection with any light is its cost. The commercial world knows that it is paying far too much for its lights; and yet the scientific world has not, until the introduction of the vacuum-tube light, been able to develop a really cheap electric light. The incandescent light is at present 25 per cent cheaper to maintain than the luminescent lamp for the same candlepower, and some experiments being carried on now will very probably soon culminate in making it many times cheaper. Of course the contact with the commercial market will soon facilitate the methods of manufacture so that it will be much cheaper in first cost also, because of the ideal simplicity of this system.

Danger

The danger from all forms of electric lights must not be overlooked in comparing them with the vacuum-tube light. Many of our large modern fires can be traced directly to the electric wires. Although we have learned by costly experience to insist upon reasonably safe wiring of buildings, yet the fact remains that every outlet, lamp socket, cut-out, and switch is what the fire underwriters call "a risk." In the vacuum-tube system, however, these dangers have all been eliminated by concentrating all of the electrical apparatus, or "live parts," in a small "safety proof" box. Fig. 3 shows the theory of this terminal box. In this is placed a transformer, the high-potential wires of which leave the



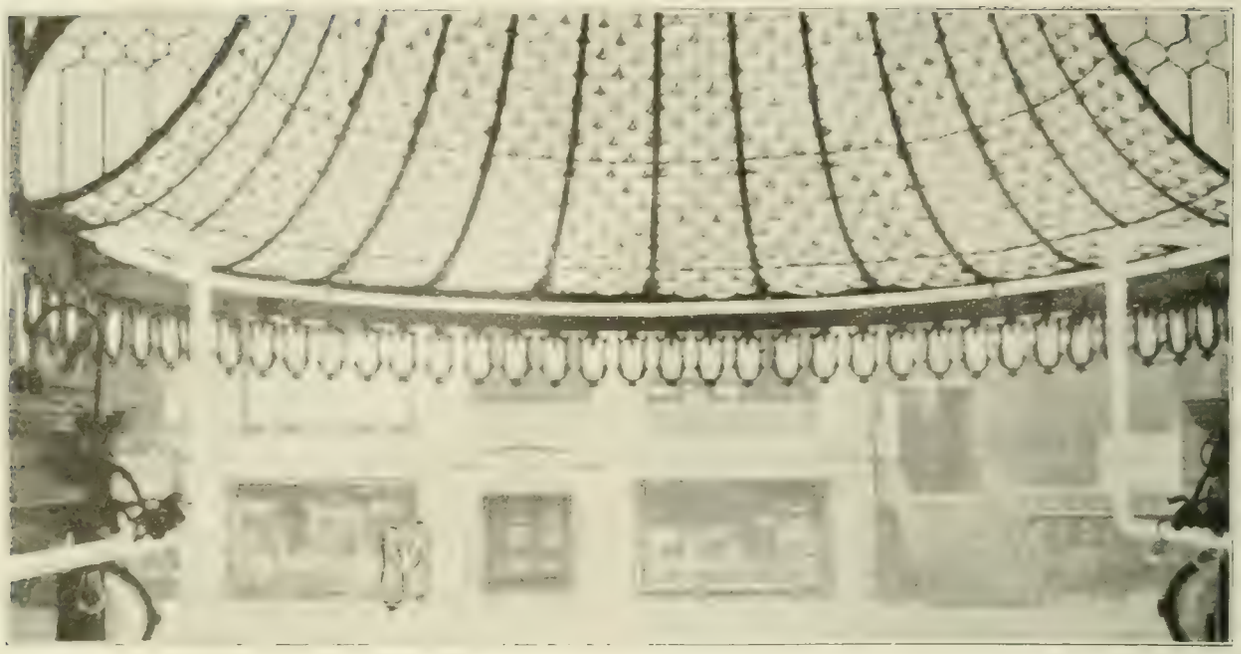


FIG. 6. VACUUM-TUBE LIGHT INSTALLED UNDER CANOPY AT ENTRANCE, 258 FIFTH AVENUE, NEW YORK CITY.

tend only a few inches to reach the electrodes of the tube. Fig. 4 is a photograph of a "safety proof" terminal box in actual operation. Out of this terminal box are run only harmless glass tubes which form a loop; and as glass is an insulator, the loop is absolutely safe to both life and property. The "safety-proof" box is supplied with 110-volt alternating current, either from the street mains or—if the source is direct current—from a small motor-generator; but this light is most effectively operated directly from the alternating-current street mains, such as are available in almost all the large cities and towns. Fig. 5 shows this same box with the front removed, giving a view of the electrodes of the tube.

This tube light can be fashioned into almost any conceivable shape, with the aid of the glass-blower's art, as will be seen from Fig. 6. This is a tube 57 feet long, and is irregular in shape in order to conform to the architectural conditions. It has been in operation for a year and a-half and during all kinds of weather, in an open vestibule on Fifth Avenue, in New York City.

Glass-Plumbing

One of the most interesting features of the Moore vacuum-tube light is the method in which it is put up. This is done by piping a room or a building with 1¾-inch clear glass tubing; and in finding a way to do this, there was created a new trade, that of "glass-plumbing." And plumbing it is; for it consists of putting up these glass tubes in lengths of about eight and a-half feet and hermetically sealing them together *in situ*. To do this, there had to be devised a whole new set of glass-blowers' instruments, such as

FIG. 7. "ARTIFICIAL DAYLIGHT" WINDOW FOR PHOTOGRAPHIC PURPOSES.

hand torches, glass-cutting tools, portable pressure-blowers, etc. The progress made in glass-plumbing will be appreciated when it is stated that a joint which at first was pronounced absolutely impossible by glass experts—and when first accomplished required a half-hour to make—can now be made in less than a minute.

Value in Photography

Aside from the field of general illumination, one of the most interesting applications of this light is for photography. For this purpose the tube is bent back and forth over the surface of a window-like metal frame, which is mounted on rollers and placed near the object to be photographed. Fig. 7 shows such a window, consisting of $43\frac{1}{2}$ feet of tubing. Some of the best photographers in the world have declared that there is no other artificial light that can be compared with this, and that the photographs obtained, especially portraits, are not surpassed even by those taken by daylight. The "artificial daylight" has an absolutely uniform intensity, a fact quickly appreciated by all who have to do with photography in any of its many branches, because natural light varies from morning till evening. Besides this, the daylight color greatly aids the operator in posing his subject, because the shades and shadows, high lights and low lights, are just the same as they would appear if the photographs were being taken by daylight; and then the perfect color value of the light reduces the amount of retouching to a minimum. Fig. 8 is a portrait of Mr. Moore, and is a sample of the excellent work that can be accomplished by this light.

Every one of the installations so far made of the Moore electric light has been an undoubted success and is still in operation. Therefore the [illegible] is rapidly becoming one of the standard methods of illumination; and it is proper that great importance be attached to it, for in simplicity it is more nearly ideal than

FIG. 8. [illegible]

any other form of light. Up to the present time the production of all kinds of artificial light has involved considerable loss in efficiency, but each succeeding light has been a little nearer the desired daylight effect than was its predecessor. In the vacuum-tube system we have a light that is correct in color and diffusion, exceedingly long-lived, with no danger, and of minimum cost—"a light that shineth like the light of day."

REPRODUCING A WHITE PINE FOREST.

View taken in western North Carolina.—In the Eastern as well as the Western part of the United States, the water supply, useful for city and farm consumption and for production of power, is menaced by forest destruction.

Life-Blood of the West

The Twelfth National Irrigation Congress Passes Resolutions of Vast Import to the Nation—Would Preserve the Public Lands for Irrigation, Settlement, and Home Building

By GUY ELLIOTT MITCHELL

THE National Irrigation Congress which met recently in El Paso, Texas, courageously assumed a position on the question of land and timber stealing which in years to come will mark it as a convention which saw the right and acted accordingly, notwithstanding that there are to-day many men in the West who are disgusted and annoyed with the attempt of this body to curtail opportunities for speculation and "graft." Courageously, because the Irrigation Congress was composed largely of Western men, and it is Western men chiefly who are profiting through the utilization and evasion of our land laws as applied to the arid region west of the one hundredth meridian.

Under the National Irrigation Act a vast work of home-building, engineering, and agriculture is opened up in the great West, yet the land and timber syndicates and speculators are endeavoring to reap the harvest ahead of the settler. The evidence which the government officials and inspectors have amassed shows in figures, in black and white, that both the Government and the intending settler are losing vast sums and opportunities annually to unscrupulous manipulators and speculators—unscrupulous but yet individually not entirely to blame, because everybody else is doing the same thing.

A Telling Arraignment

The following quotation from the annual report of Secretary Hitchcock of the Interior Department, regarding the operation of the Timber and Stone Law, may be taken as a single example:

"The reports of the special agents of this Department in the field show that at some of the local land offices carloads of entry men arrive at a time, every one of whom makes entry under the Timber and Stone Act. The cost of 160 acres of land under that act, and the ac-

[illegible]

"From the foregoing it will be seen that the duty of protecting the public domain from the inroads of those who seek to despoil it is an onerous one, and is a matter that should receive the early and careful consideration of the Congress."

The Twelfth National Irrigation Congress stood squarely upon the platform that the public resources of the West—its land, its water, and its timber—should be administered for the benefit of the people. Furthermore, while it endorsed the provisions of the National Irrigation Law and the work of the Government under it, it recognized that the reclamation of the West through the funds provided by that law must be a comparatively slow process; and it suggested advanced legislation by which additional appropriations should be made to carry on the work more rapidly and in a manner commensurate with the greatness of the project.

To Allow Local Capital to Co-operate

Recognizing the feature of the law which requires the repayment of the government expenditures by the settlers who occupy the land, it further suggested that where localities desired to advance the money themselves, they should be allowed to organize into "Irrigation Districts;" raise funds by the sale of bonds, under the approval of the Secretary of the Interior; and practically turn the money over to the Government for construction of projects. The scope

[illegible]

of these resolutions would provide for a work of as great magnitude and importance as the river and harbor construction work.

Among the important resolutions passed were the following:

ernment to the Reclamation Fund, to be used in the construction of projects approved by the Secretary of the Interior, and to be repaid by the owners of lands benefited, in accordance with the provisions of the present law.

"But we would not have the West depend alone upon national aid in the development of its resources; and urge the several Western

FORESTED MOUNTAIN SLOPES IN NORTHERN CALIFORNIA.

To Augment the Irrigation Construction Fund

"We fully recognize that the funds now available are inadequate to the realization of the National Irrigation policy upon a scale commensurate with the opportunities of the West and the needs of the nation; and we favor a non-interest-bearing loan by the Government to the Reclamation Fund, to be used in the construction of projects approved by the Secretary of the Interior, and to be repaid by the owners of lands benefited, in accordance with the provisions of the present law.

"But we would not have the West depend alone upon national aid in the development of its resources; and urge the several Western States and Territories to adopt legislation providing for the formation of Irrigation Districts which shall be able to raise funds by the sale of bonds, said Districts to be organized only upon approval by the Secretary of the Interior, who shall employ the Engineers of the Reclamation Service in the construction of district irrigation work. By this means the

Reclamation Fund will be supplemented to the extent of millions of dollars by every State and Territory, while the benefits of national administration will be vastly extended. We commend this subject to the earnest attention of the legislatures of our Western States and Territories."

OREGON FIRS.

How Forests Affect Water Supply

Leaving aside the fact that under the Timber and Stone Law, which allows syndicates to hire men to use their rights and acquire 160 acres each of the finest timber land in the world, worth as Secretary Hitchcock says, $50 or $100 an acre, for $4.50 an acre, and thus obtain single ownerships of thousands of acres of magnificent timber-land, these cut more than one-half of the timber, the method of private lumbering are usually such as to denude entire

CONSERVATIVE FORESTRY.—PRESERVING THE FOREST; ALSO THE WATER SUPPLY.
A scene on the Biltmore Estate, North Carolina.

LOGGING ENCROACHMENTS IN THE STATE OF WASHINGTON

DESTRUCTIVE LUMBERING IN MINNESOTA.
Burned stump land, Carlton County.

by dry watersheds. On the other hand, where the slopes are densely covered with trees and brush, the melting is gradual and the run-off slow and protracted. This means that forest destruction is the destruction of the water supply, and in the irrigated region this is fatal.

Land-Law Reform an Old Question

For years and years, Congress has been petitioned and urged to reform the land laws of the West. Presidents, Secretaries of the Interior, and Commissioners of the General Land Office, despairing of enforcing laws framed for the purpose of evasion, have officially besought Congress to repeal them; but it is a sinister fact that sufficient Western influence has already appeared to thwart all such demands. Meanwhile the country has been losing its most precious and valuable heritage, while the people, little understanding the birthright which they have been exchanging for a mess of pottage, have looked apathetically on.

There were statesmen in the recent Irrigation Congress, and they were in the majority. They voiced the sentiment of the President in his message to Congress, and in his splendid talks to the people of the West, urging that the best use be made of their resources, and that patriotic endeavor be made to bring forth the greatest good for the greatest number.

A Ringing Message

In his second message to Congress, the President said:

"Few subjects of more importance have been taken up by the Congress in recent years than the inauguration of the system of nationally aided irrigation for the arid regions of the far West. A good beginning therein has been made. Now that this policy of national irrigation has been adopted, the need of thorough and scientific forest protection will grow more rapidly than ever throughout the public-land States.

"So far as they are available for agriculture, and to whatever extent they may be reclaimed under the National Irrigation Law, the remaining public lands should be held rigidly for the home-builder, the settler who lives on his land —and for no one else. In their actual use, the Desert Land Law, the Timber and Stone Law, and the Commutation clause of the Homestead Law have been so perverted from the intention with which they were enacted as to permit the acquisition of large areas of the public domain for other than actual settlers, and the consequent prevention of settlement."

The Old Homestead Spirit

In the President's speeches during his last western tour, the following is but

one extract of a score or more along the same broad lines:

"We should handle all problems [illegible] those of forestry and of the preservation and use of our waters from the standpoint of the prominent interests of the future welfare to our region—the man who comes on and to get what he can out of the soil, and leave, having exploited the country, but who comes to stay, therein, to bring up his children, and to leave them the heritage in the country not merely unimpaired but if possible even improved.

"The one acid test of all public land legislation should be—Does it help to make and keep prosperous homes? If it does, the legislation is good. If it does not, the legislation is bad. Certain of our land laws however [illegible]

[illegible] use."

"You will [illegible]

And [illegible] ing, what will [illegible]

Cost in Engineering Work

The Necessity for its Limitation

By HENRY L. BALLANTYNE

THE relations of the engineer and of engineering work to industrial and commercial affairs are varied and quite complex. There are engineers who are engaged wholly in research and other forms of purely scientific work; there are engineers engaged in invention and design, the making of analyses, and other purely technical work for industrial and commercial interests; and, again, there are engineers who, possessing a certain amount of scientific and technical knowledge, are required to act as advisers and interpreters to those who have engineering work to do but who are not familiar with engineering requirements. To this class belongs the engineer now included broadly under the title of "Consulting Engineer," who is required to take up many considerations other than the purely scientific and technical. Prominent among these is the question of cost, and the necessity for limiting the amount of money to be used in the accomplishment of a given purpose.

It is this phase of the engineer's work that will be considered at this time; and, for the sake of simplicity, we shall confine our attention to the work of the engineer in his strictly professional capacity, and in connection more particularly with private enterprises of an industrial character.

The company, or individual, by whom the engineer is employed are men who engage in business that they may forward their own interests by the making of money. It is not the business man's purpose, primarily, to construct perfect engineering structures or to produce the most perfect article for sale. He does require an efficient structure or mechanism to do certain work, and he is required to produce the best article that can be made within certain limits; these limits, however, are not necessarily such as are set by the state of the art in question, but the conditions by and under which it is possible to earn a satisfactory profit and establish a business of permanent value. The business man, therefore, when he consults an engineer, does so in order that he may be enabled to construct a building, erect a bridge, or install a power plant so that by its use he may obtain the greatest advantage possible out of a certain line of industrial effort. The financial consideration is of fundamental importance in every problem of the kind now before us, and under this head is included the subject of investment and cost of work done, of which the cost of engineering work is frequently a very important factor.

Professor Rankine has defined the engineer as "he who, by act and science, makes the mechanical properties of matter serve the ends of man." To be an engineer requires that a man be acquainted with certain natural laws, the nature and properties of various materials, and the arts developed by man, subject to these laws, for turning these materials to serve the needs of mankind. To serve those needs, not only must the design, materials, and construction be good, but the work must be done at a cost which, under the conditions existing and for the purpose intended, will produce results that will compare favorably with those of other work which has been constructed for a similar purpose and with which it must compete.

Another writer, A. M. Wellington, defines engineering, widely but not inaptly, as "the art of doing that well with one dollar which any bungler can do with two after a fashion." The engineer, therefore, must procure his results in such a way that the cost of the materials used is reasonable; and the materials used and the manner of using them must be so adjusted to conditions that the user—the business man—may be able to show the best return possible as a result of his operations.

To perform his duties successfully, the engineer should be so qualified that, through the possession of special knowledge, he can furnish to the non-technical man such information as he requires on engineering subjects; design and execute work requiring special technical skill and knowledge; and be able so to appreciate and understand the conditions and requirements of the business man, that it is possible to produce work that will answer its purpose to the fullest extent.

The qualities and training that will fit a man for the duties and responsibilities of the engineer are very considerable. There must be natural aptitude and ability, technical training, and a broad experience.

The importance to the engineer of a sound technical education is pretty generally recognized; also the necessity for a knowledge of the best materials and equipment to use, and the proper method of design and construction of engineering work. Having been endowed with reasonable aptitude and ability, the foundation on which success in engineering work depends is a thorough technical education and training. To this, however, must be added a knowledge of and a familiarity with the practical conditions under which engineering work is done; the methods of manufacture and the relative merits of different makes of goods; the adaptability of special kinds of equipment; cost and efficiency; and a knowledge of human nature, business methods, and a multitude of other points on which knowledge can be obtained only by living with or under business conditions as they actually exist. This experience enables a man to act with judgment—the basis for which is, primarily, the ability to make comparisons—and also to go forward with promptness and confidence, which are essential factors to success.

What the duty and province of the engineer is, and what his responsibility to his client in regard to financial considerations, are subjects on which considerable difference of opinion exists. It may

be considered by some that the engineer who studies the physical conditions under which certain work must be done, who accomplishes a given object in a simple and economical manner and requires the use of only the most suitable materials and construction, has done all that is required of him. But this, frequently, is not enough. The work must be done with due consideration for the amount of money which is available for the purpose, or which it is justifiable to invest in the enterprise. A consideration of total cost and a wise limitation of investment, are important features in engineering work. What the engineer's relation to these problems shall be, will vary greatly; and his opportunity to consider the broad questions of policy and the desirability of investment will also vary greatly. In some cases and for some engineers, this aspect of the problem may be entirely outside his field. On the other hand, there is a tendency at the present time towards a broader and more comprehensive view of conditions and requirements; and, just as there are lawyers who are known as "business" lawyers, so there are engineers who might be known as "business" engineers. To these, particularly, comes the duty and responsibility of considering the desirability of investment and the possibility of return.

To the business man the financial consideration is of the first importance in the ordinary engineering problem, and must be provided for by him, in co-operation, as far as possible — with the engineer. Some engineers — more particularly the younger men—are not inclined to consider financial matters of the same importance as do their client, the business man, and frequently feel that a barrier is being placed in their way more or less unnecessarily, instead of as one of the set and recognized conditions under which they must work. This is due, largely, to a misunderstanding of, and a lack of appreciation of, the limitations and conditions by which the business man is bound, and with which he must comply just as surely and as truly as the engineer must comply with the laws and forces which govern him in the design and construction of his work. The ability to understand and appreciate the laws of business, and a knowledge of business

of or disregard for the facts ended disastrously.

When a man builds a house, he must count the cost; he must provide funds with which to pay the builder; he must figure out the interest on the investment, allow for depreciation and maintenance, and still have means to pay his tax bill and many others. The primary purpose of building a house is to provide a place in which to live. Therefore, no matter how well the house may be planned, how artistic its appearance or how substantial its construction, unless the person who proposes to live in the house can afford to pay these expenses for the purpose for which the structure was intended, it is a failure.

An engineer may design a plant which is technically a model. Everything about it may be of the best, and be bought at the best prices for which such material and equipment can be obtained; buildings may be erected and machinery installed under the most skilled superintendence and at low cost, and may be able to turn out the finest product possible. All this may be so; and yet, as a business enterprise, for the purpose and under the conditions for which it was built, the plant may be a commercial failure and be comparatively valueless when completed, owing to a lack of sound judgment, and neglect to count the whole cost before beginning work. In this case the result may be that, though the plant is a fine one and though it is possible to pay the contractors and others in a satisfactory manner, yet the management finally finds itself face to face with the fact that it has used up its credit and has not sufficient available capital with which to carry on a profitable business.

Or suppose a company wishes to undertake the manufacture of some article for general commercial use. The article in question will not command in the market more than a certain price, and only a limited number may be required. It will be necessary so to limit the investment, and to allow such a margin between selling and manufacturing cost prices as that all expenses will be covered, interest on plant and other equipment paid, depreciation and cost of maintenance provided for, and payment made of salaries, labor, interest on borrowed money, selling and other expenses, and still a margin be left for the owner or shareholders. Unless the business can do this, it, too, is a failure.

It is therefore well for the engineer to bear in mind the following points:

That the business man is limited by conditions as fixed and unalterable as the laws which govern the engineer; that he must not only be able to provide the necessary capital with which to build a plant, but must earn interest on the capital invested, must provide for depreciation, make repairs, and buy new equipment, must buy raw materials, must pay labor, selling, and other expenses, must show a profit for the owners or shareholders, and, with all this, must still sell the product at such a price that it will find a ready sale in competition with the product of other companies who are adopting every means possible to reduce costs and to be able in this way to reduce the selling price and control the market.

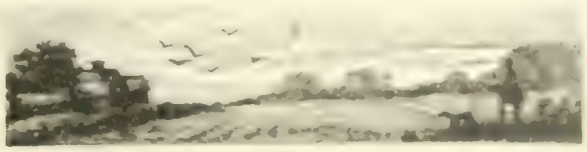
The engineer should also bear in mind that the business man must not only buy cheaply, operate skilfully, and sell well, but must do the maximum amount of business possible with available capital, and still keep his expenses at a minimum. This can be done only by limiting the amount invested in the plant, the result being that not only is more money left with which to do business, but a reduction is made in interest charges, taxes, and other expenses which, once incurred, cannot be eliminated by even the most efficient management.

It must also be borne in mind that it is the duty of the engineer to produce the most efficient equipment obtainable with the available capital, and that the earning capacity of an enterprise should be determined as accurately as possible before undertaking such enterprise. Further, that where the experience of the projectors is limited or the enterprise new and untried, a conservative attitude should be assumed, and only a sufficient amount invested to determine the value of the undertaking; and that no man or group of men should invest in an experimental undertaking more than they can afford to lose and still maintain themselves.

It is also recommended that the engineer acquaint himself with the general

methods of financiers and business men, so that he may understand more freely the methods and conditions to which the business man is bound; and that he acquire a general knowledge of the principles of accounting, by which the business man determines the results of his operations.

The engineer who most fully accommodates himself to the needs of his client, the business man, and thereby enables him to conduct a successful business will



Life's Tragedies

THOU art not to be pitied with the
The threat of midnight when the forelands moan
And all the woods are mute
Dread and despair and anguish, the great things
That sit like crowns upon the brows of Kings
Or that Queens weep about—
If by these only thou hast been accursed,
Grieve not too much; for these are not the worst

That bring the furrows to man's face; the years,
Falling and fall'n in vain,
That turn the gold to gray upon his head;
And the dull days to disappointment wed,
And pain that follows pain,
That make life bitter in the mouth, and strew
The dead with roses, but the quick with yew.

Better a wide and windy world, and scope
For rise and downfall of a mighty hope,
Than many little ills;
Better the sudden horror, the swift wrong,
Than doubts and cares that die not, and the long
Monotony that kills,
The empty dawns, pale stars, and narrow skies,
Mean hopes, mean fears, mean sorrows, and mean sighs.

THE ELMS AT ST. CHARLES.

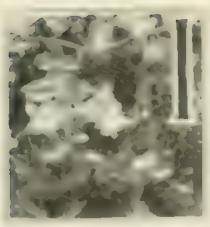
The pictorial charm of this photograph is obvious enough; but the elements on which its appeal depends are not at first glance apparent. As a matter of fact, the beauty of the arrangement is found in the volute curve which bounds the foliage mass of the more distant elm, and connects that mass with the grassy roadside. Subordinate beauty is found in the repetition of lines in the branches of the nearer and farther elms. As a matter of pure technique, this print is a good example of "machine development," everything possible to be represented by the scene being well preserved in the negative.

Principles of Artistic Photography

Regulating Color Effects—Printing Processes—Interior Work, Portraits, Landscapes, and Other Special Applications

Fourth and Final Paper*

By Louis A. Lamb



IT is justifiable to assume that the photographer is now prepared to make negatives of "standard quality," of well-chosen and suitably arranged subjects—in short, such negatives as are worth the labor and expense of printing. For the sake of a clear understanding, it may be well to recapitulate the prime essentials of "quality" in a negative. Naturally, truthfulness is entitled to first place; and under this head will be comprised correct "tonality;" correct lighting, to display the essential character of the subject; proper focusing, to reveal differences in contour and texture; and freedom from damaging distortion of image, through ill-advised choice of lenses or faulty position of the camera.

The "Standard" Negative

The ideal negative is one of moderate density in the opaque parts corresponding to the highest lights, and sufficiently veiled with the silver deposit even in the deepest shadows, or transparent parts, to render gradation in the darks as well as in the lights. Between the extremes of absolute opacity, to represent the extreme high note of the total gamut, and a small area of great transparency, standing for the small mass of very dense shadow in the subject, there should be a sensibly even graduation of the deposit in conformity with the range of light and shade depicted.

Color Effects

Except as non-actinic colors in the sub-

This beautiful [illegible] to [illegible] the peculiar softening of [illegible] and to the arrangement whereby the [illegible] to add the story of the [illegible]

* Note.—The first, second, and third papers of this series appeared in February, March, and April respectively. Another paper from Mr. Lamb, dealing with some topic of special interest in photography, may be looked for in the near future.

SURF AT NANTUCKET.

A good example of skilful print manipulation, the work of Mr. Earl H. Reed. The negative of the wave, being of necessity timed to arrest motion, showed little of the sky detail which the operator thought essential to the picture. Accordingly he "blocked out" the sky with opaque paper while printing the wave, and subsequently printed in a Jackson Park (Chicago) sky by "masking" out the wave print. A little judicious "sunning down" of the junction line makes the "dodge" imperceptible. The effect is certainly harmonious and pleasing, whereas a blank sky would have been cold and forbidding.

ject introduce errors of scale, it is quite feasible to obtain negatives of this standard quality by the "machine" method of development which has been recommended in this series of papers. But the use of color-sensitive plates and the adjusted ray filters recommended by the plate makers puts it within the scope of any worker to obtain "standard negatives" irrespective of the color difficulties which his work may involve, if he will only take the pains to learn the specific qualities of the available brands of plates, and the equally essential facts about the light filters with which they are designed to be used.

The novice is deluded too frequently by the belief that an exceedingly brilliant negative is necessary for good results in the printing frame. As a matter of fact, such negatives are of little merit, yielding prints harsh in quality and false in tonality. A negative of that quality which we commonly associate with slides for the projection lantern, is most unsatisfactory for printing; and if it is possible to duplicate the exposure under more favorable conditions it should be done. Speaking generally, we may say that there is no branch of photography in which "clear glass and black" negatives are desirable except that which has to do with reproductions for the printing press—line copying or half-tone screen work.

Copying Flat Subjects

When the worker desires to copy drawings or flat subjects, having in mind the most intense possible relief for the blacks and wishing whites absolutely free from tint, he can easily obtain the proper kind of negatives by using slow emulsions or "contrast plates," giving long exposures, and developing in a solution of hydroquinone and bromide of potassium. The following formula will be found excellent for this purpose, but it is not at all suitable for pictorial work:

DEVELOPER FOR CONTRAST PLATES

Water	12 ounces
Hydroquinone	60 grains
Sulphite of soda (dry)	120 grains
Carbonate of soda (dry)	240 grains
Bromide of potassium	30 grains

This developer works slowly at temperatures lower than 70 degrees Fahrenheit, even in cases of violent over-exposure; but it will reproduce jet black lines as absolutely clear glass, and white paper

with a silver deposit so opaque that almost any amount of printing can be given without degrading the high lights of the print.

Printing Processes

Innumerable printing processes are at the command of the photographer, all good for certain purposes, and the choice in specific cases depending entirely on

LIBRARY INTERIOR.

small for the plate. Inasmuch, however, as this picture
the lens at full aperture F 6.8, it
ful example of the scope

the needs of the moment. Permanency, pictorial effect, and extreme sharpness are the three qualities ordinarily considered in selecting a printing paper. If an immutable record is wanted, there can be no doubt that the printer will choose a platinotype stock, or one of the "carbon" papers suitable for toning in chloro-platinite of potassium; or a carbon tissue in some of the permanent pigments — engraving black or iron-oxide red prefer-

easy to work; properly fixed and washed, they give prints of very great permanency; and they enable anyone to turn out a great amount of uniform work in a short time, regardless of sun or clouds.

Those who pursue photography principally as an adjunct of literature, for illustrations, will require papers of the gelatino-chloride class, the glossy, sun-printing papers, usually described under the mystic term "P. O. P." Such prints,

SPRINGTIME IN THE MARSHES.

This photograph shows the value of long-focus lenses in pictorial work. It was made with a lens of 17.25 inches' focal length, at aperture F/11, the intention being to preserve the feeling of vague, spring-like atmosphere in the distance. The image was focused sharply as to the foremost trees; but every receding plane is less keenly defined to the very horizon, where the forms are only suggested to the imagination. As a study in the management of lines and groups, this picture is well worth attention and analysis.

properly toned in gold, and given a [illegible] surface by drying in contact with a japanned or ferrotype plate, are almost universally preferred by process engravers. For permanent records, however, it is open to question whether the amateur can be trusted to handle printing-out paper successfully. Unless every molecule of any compound containing sulphur is eliminated from the image film, these

PORTRAIT OF BABY.

prints will deteriorate under the action of the air, and in a few years turn yellow or fade out entirely. The writer has prints on gaslight papers, printed and developed nearly eight years ago, which are still as good as they ever were, though they were only slightly fixed and merely rinsed in water; but prints on glossy paper, made at the same time and carefully washed, have discolored and faded so as to be useless.

The seeker for laurels as a "pictorialist" will use platinotype paper, mercury toned; or one of the ferro-silver papers sold under the trade name "sepia;" or more likely he will turn to "gum bichromate" printing as the most likely way to fame.

Students of design and illustrators frequently have occasion to make drawings [illegible] Any kind of [illegible] coated with a [illegible] gum-[illegible] sold [illegible] too greatly [illegible] diluted [illegible] over with a solution [illegible]

60 grains to the ounce, and dried in the dark. Prints on this paper may be toned in gold if desired, or drawings in waterproof india ink may be made over the silver image. When the pen-work is finished, all the photographic color may be discharged by a mercuric chloride solution and, after washing and drying, you will have a line drawing suitable for zinc etching.

Blue-Prints

Ordinary "blue-prints" are of great utility, and so cheap as to be of value in innumerable departments of industry. No [illegible] bridge, or [illegible] constructed, no bridge erected—nothing involving structural technology is done anywhere in the world, without the aid of "blue-prints." The process is of such

HOME PORTRAITURE.

In making portraits in the house, the amateur usually has extreme difficulty in giving his subject predominance over the furniture and wall-paper. Where short-focus lenses are used, this is a trouble hard to correct without introducing general "fuzziness." The true "portrait effect" can be obtained, however, by bringing the lens as close as possible to the sitter and employing a suitable draw of bellows. In this way, if the focus is sharp on the subject, the background and accessories are left indistinct. In all work of this kind, great care is necessary in order to have lines, masses, and draperies agreeably arranged.

value and utility that we may as well give a formula for the solution:

BLUE-PRINT SOLUTION

Ammonia-Citrate of Iron.....80 grains
Ferricyanide of Potash (red prussiate) ..... 1 drachm

Dissolve separately, each in an ounce of pure water. Mix just before use; and apply to any good, "hard" paper, with a swab of cotton. Dry paper in the dark, and print in direct sunshine until shadows are "bronzed" or gray. Develop in an excess of pure water.

These prints are very durable and well worth making, even from negatives which seem hardly to justify the use of costlier papers. As in the case of the "plain-salted" paper just described, it is possible to draw in pen-and-ink style over a blue-print image, subsequently bleaching out the blue color by immersing the print in weak alkaline solutions — ammonia or carbonate of soda.

Platinotype Process

For the worker who desires to display the utmost individuality in his printing, two media are available—platinotype and gum bichromate. The former process depends on prepared papers, of which there are many good brands calling for similar treatment and amenable to similar manipulative variations, giving a range of tones from flesh pink to intense black. This process also permits of local development, and restraint with glycerin, so that the accomplished artist can obtain effects closely assimilating those of a wash-drawing.

Gum Bichromate Process

Gum bichromate printing is distinctively a "home" affair; for the reason that the worker does everything himself, and pays for nothing but the raw materials. He may choose such papers as he likes, any pigments which are agreeable; and, by proper variation of his materials, he can produce pictures either very cold and sharp, or very sympathetic and warm, with all degrees of intermediate gradation.

Briefly, the process consists in the following steps:

Stout paper, preferably slightly sized, is evenly painted over with a mixture of thick gum arabic mucilage, coloring matter, and a small percentage of bichromate of potassium. The coated paper is dried in the dark, and exposed under a negative as long as would be required to give a fair print on "printing-out" paper. The printed paper is then immersed in cold water to dissolve away the parts of the pigmented surface on which the light has not acted, or acted only slightly. The film is rendered insoluble in the clear glass parts of a negative, by a very short exposure to full sunlight. Hence well-graded negatives are needed.

If finer detail is desired, it is better to substitute glue or gelatine for the gum arabic. In this case a shorter exposure will suffice, and warm or hot water may be used for the development of the print. Mixtures of gum and glue enable the worker to gauge the solubility or sensitiveness of his film with such accuracy that it is easily within his power to produce prints of any desired sharpness or "fuzziness."

Descriptions of the "gum" process usually lead the novice into the error of thinking it difficult. The fact is that it is by odds the quickest and easiest of printing processes, and the most beautiful if suitable negatives are provided. Glossy papers give better prints for commercial or industrial purposes; but for the pictorial enthusiast, gum prints cannot be surpassed. Plain office mucilage may be

used, or dry gum arabic may be ground up to a thick syrup with water. A suitable pigment—either dry or in the form of must water-colors—is added and the

THE LOVER OF HORSE FLESH.

In this study portrait Mr. Gates employed the method outlined by the late Colonel Wood in his article, "Artistic Suggestion." That there is a subtle charm to this process is undeniable in view of the fact that no sketch by Meissonier can equal the beauty shown has failed to discern in it, spontaneously and without "mounting" or retouching, the "happy" qualities of the artist and his love of hunters and horseflesh. Mr. Gates believes that the success of the picture is due largely to the [illegible] extra effort to impress upon the subject [illegible] moment of exposure.

mixture is made sensitive with a few drops of a saturated solution of bichromate of potash. Ordinary rubber-bound bristle brushes and "blenders" may be used for the production of an even coating on the paper. Architects' detail paper

Interior Views

Special classes of work will call for close study by the worker, and no manual or article can take the place of brains and discrimination. In interior work, short-focus lenses usually will be chosen:

the camera will be placed so as to avoid reflections from picture-glasses or the direct light of windows. Rapid "non-halation" plates should be used, and liberal exposures be allowed to compensate for the small working apertures of wide-angle lenses. It is obvious that the result will depend largely on the ability of the photographer to arrange his materials harmoniously. Taste and experience used conjointly will solve the most difficult problems. These points should be remembered:

Avoid the temptation to include figures in dimly-lighted interior views, since nothing but failure can result.

Remember that successful interior views take from fifteen minutes' to an hour's exposure, according to the lighting and the color of the decorations. If the wall hangings are dark, a much longer exposure will be required than if the decorative scheme is light; and if the room is large, a smaller aperture of lens and a longer exposure will be necessary.

Portraiture

Portraiture is a special field. It is difficult to make any rules for the professional; but the pictorial photographer can do no better than consider the system which has been made so successful by Mr. Solon L. Gates, of Chicago. His theory is that the proper representation of character demands a keen appreciation of the character by the photographer, and a conscious effort on the part of the camera worker to mould the sitter to the preconceived ideal during the time of the exposure. Mr. Gates therefore prefers a long exposure, because he is enabled thereby to have the sitter longer under the influence of his suggestion. All the time that the shutter is open, the photographer should have the characteristic aspect of the subject firmly fixed in his mind; and, if proper attention has been given in advance to the accessories, a most vital portrait will result.

Landscapes and Salon Pictures

In landscape photography, and in all work of the so-called *salon* class, the prerequisite is a clear conception of the idea to be impressed on the mind of the observer. It is essential that all unimportant elements be eliminated, and that the characteristic aspects of the subject be emphasized. This involves close study, both on the ground glass and in advance of the attempt to photograph the subject. In fine, the best photographic work is done, and always will be done, in the mind of the worker, long before he goes out with his lenses and sensitive plates. *Any photographic system which neglects the advance study of subjects and fails to insist on the mental working-out of themes, is deficient in an essential particular. Before the building of the engine, there must be wrought out a complete set of detail drawings. Before the successful photograph, there must be a maturely wrought out conception of the final print. Intellectuality is the test of photography, as it is the final test of all technology.* The successful man is the man who has thought best and deepest into the essentials of his business. Failure is impossible to the camera worker who approaches the craft with zeal and forethought.

Aërial Cableways

A New Method of Transportation that Defies Topographical Conditions and is Adaptable to Many Uses

By RUTLEDGE RUTHERFORD

Special Correspondent, The Technical World

To be suspended by a wire rope with the earth 2,000 feet below, and the sky and a rust-veiled mountain peak above, is a thrilling kind of experience that not many are anxious to undergo, but one that is often necessary in mining operations about Ouray, Colorado. At a gold mine near that town, a wire-rope tramway is in daily operation to haul the ore from the mines over the mountain peak to the smelter. The cable reaches across a yawning valley between two mountains, one of which towers majestically above the other. In hauling these loads of ore, it is often necessary for a man to accompany the car on its remarkable journey; and many of the workmen who live near the railway go to and from the mine in the aërial tramcars, twice a day being swung across the 3,000 feet of space over the valley and up the mountain side.

This, however, is not the only wire-rope tramway in the West—they are found in several other parts of the United States, for that matter—but this particular one would be hard to excel as a thrill-producer to persons fond of exciting experiences. Riding in an airship could scarcely be more exciting, while loping the loop and other amusements of the thrilling kind would appear tame in comparison to the person who has once "swung-the-valley" in a tramcar of the Ouray wire-rope railway.

At Park City, Utah, is another of these tramways of unusual interest because it hauls its loads of passengers and freight high in the air above the city. There is another that speeds its cars along over mountains and valleys in the vicinity of Lemmy, Idaho. Telluride, Col., boasts of one of exceptional length. Others noted for their height above ground and their length are in operation at Chinese Camp, Cal.; Silverton, B. C.; and Encampment, Wyo. While in the East tramways of similar type are employed at Sandy Hill, N. Y., and Vulcan, W. Va. In fact, wire-rope cable lines are springing into use

AËRIAL WIRE-ROPE TRAMWAY AT OURAY, COL.
The cars are used for carrying gold ore across the 3,000-foot span.

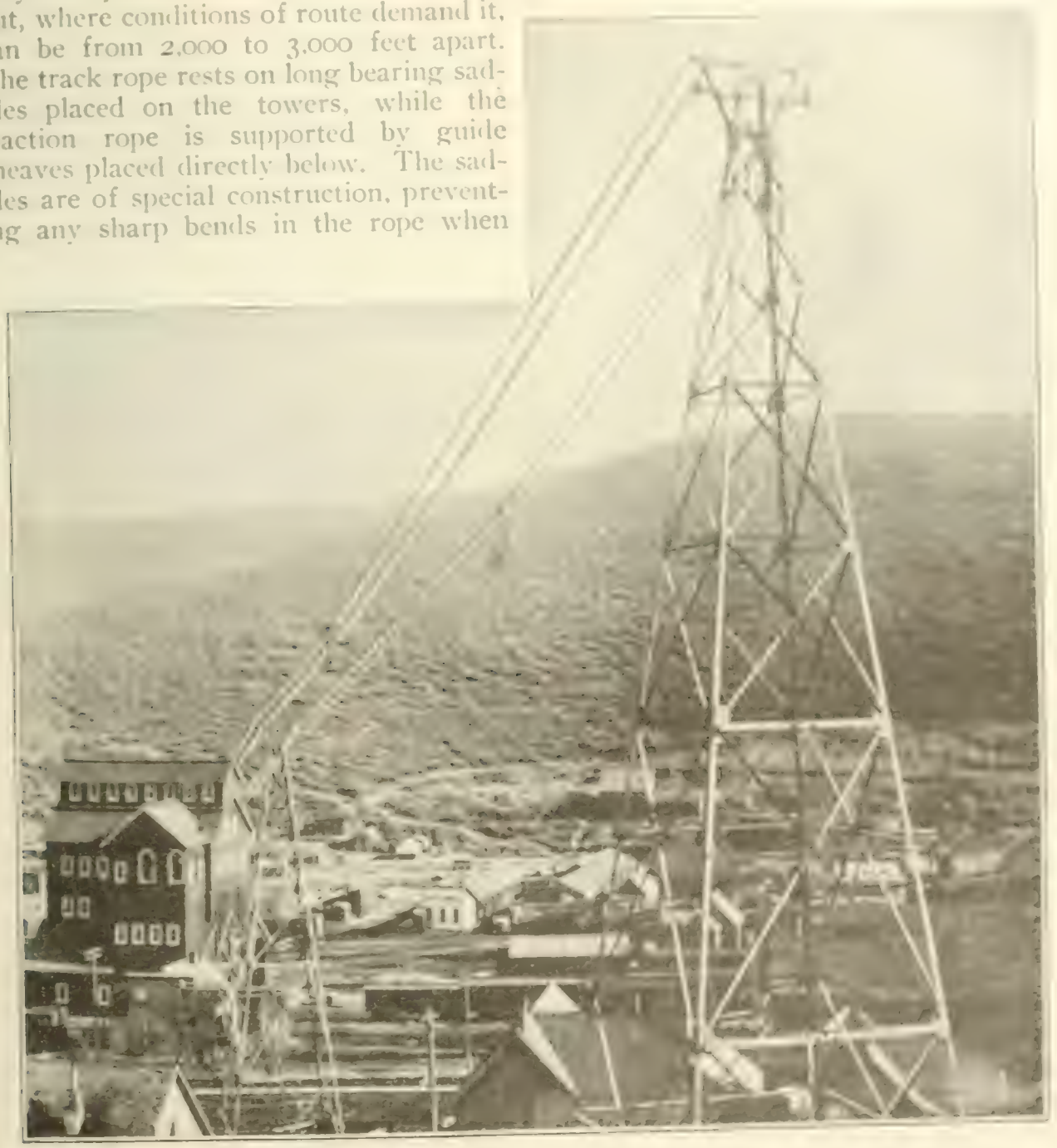
throughout the country, both east and west.

The lines mentioned have been built for freight traffic, except on special occasions and when it is necessary to haul the workmen in the cars to accompany the load or to transport them hurriedly to or from points along the line. In Europe, however, aërial tramways have become of such importance that they have been successfully experimented with as a new and novel means of hauling persons; and two or three lines have been built for passenger traffic exclusively. Some predict that they will eventually work themselves into the passenger field in America, as their construction is much cheaper than that of railroads, they can be made to penetrate regions railroads could never reach, and the cars can be made to travel much faster than railroad trains.

Cars employed on the wire-rope tram-

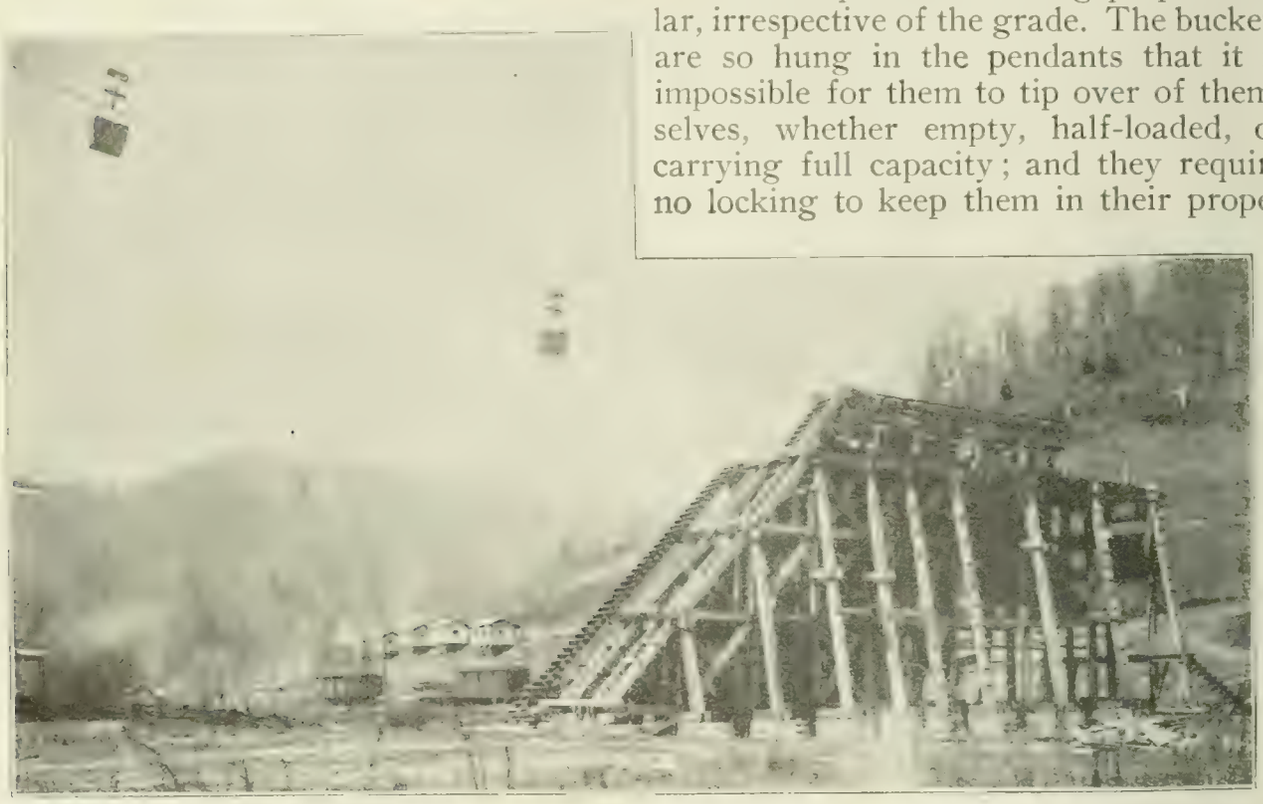
ways in America look like huge buckets or more like big steel bathtubs. In these, suspended from the wire cables above, materials such as ore, coal, grain, stone, sand, timber, etc., can be economically transported over practically any condition of country or length of line, and in any quantities desired.

The cables or wire ropes of the automatic tramways in the newest types, as shown in the illustrations, are supported by towers, which are usually constructed of wood, although steel construction is frequent. The number, height, and spacing of the towers depend mainly upon the profile of the ground. On level stretches they are placed usually 250 feet apart, but, where conditions of route demand it, can be from 2,000 to 3,000 feet apart. The track rope rests on long bearing saddles placed on the towers, while the traction rope is supported by guide sheaves placed directly below. The saddles are of special construction, preventing any sharp bends in the rope when



AËRIAL CARS HAULING SILVER ORE AT PARK CITY, UTAH.

rope was necessarily raised a distance of at least four feet when the carriers passed over a tower. The strain thus produced in passing over a sharp bend or knuckle, was enormous, and not infrequently caused considerable trouble. In the new cable of the automatic system, this feature is entirely avoided, and the wear upon the cable and rolling stock greatly reduced. A skip is used on the towers to guide the traction rope in the groove of the sheave in case it is misplaced from any cause.



AËRIAL CARS DESCENDING AND ASCENDING FROM A MOUNTAIN PEAK COAL MINE AT VULCAN, WEST VIRGINIA.

The clips to which the carriers are attached are spaced according to the desired tonnage. These clips are of flat construction, with button-shaped ends. They are attached to the traction rope by means of two specially forged bands, which encircle the rope and have the "lay" of the rope forged in them. Owing to the positive hold on the rope and its double security, it is absolutely impossible for the carriers to slip on the line, irrespective of the grade or load. It is possible to operate the rope under or over the guide sheaves. The carriers cannot become detached from the rope until it is desired to effect this, and the carrier is always sure of being carried from one end of the line to the other.

The type of carrier used in America is usually of 6½ cubic feet capacity, or more. The carrier is hung in a pendant, which in turn is attached to a carriage consisting of a yoke and two special cast-steel sheaves for traveling over the track ropes. This arrangement allows free movement, thereby permitting the entire bucket and pendant to hang perpendicular, irrespective of the grade. The buckets are so hung in the pendants that it is impossible for them to tip over of themselves, whether empty, half-loaded, or carrying full capacity; and they require no locking to keep them in their proper position. The sheaves have brass bushings, and are fitted with malleable oil-cups for oiling the journals. To the bottom of the bucket is attached a pin, used in connection with the automatic discharging devices at the unloading terminal. In the pendant is placed the clip-frame, in which the traction rope clip is engaged. This frame consists of a snow-proof housing and two trips operated by a sliding frame, all being made of the best malleable iron and cast steel.

When a carrier is in transit, the clip is engaged between two trips; but when the bucket reaches a terminal, one trip is dropped back, allowing the clip to pass out of the housing, and thus detaching the bucket from the tramway. The trip is moved back by a sliding frame, which is raised by a curved bar at each terminal. In a similar fashion, a bucket is also at-

tached to the clip. After which the two clips are locked to prevent them from opening. This entire operation is automatic, requiring no attendance whatsoever. The clip is not held rigidly on the clip-frame, but has sufficient play under all circumstances. For carrying grain in sacks, lumber, bales, merchandise, logs, water, and other like materials, special carriers are provided. Intermediate loading or unloading stations may be located at any point along the line.

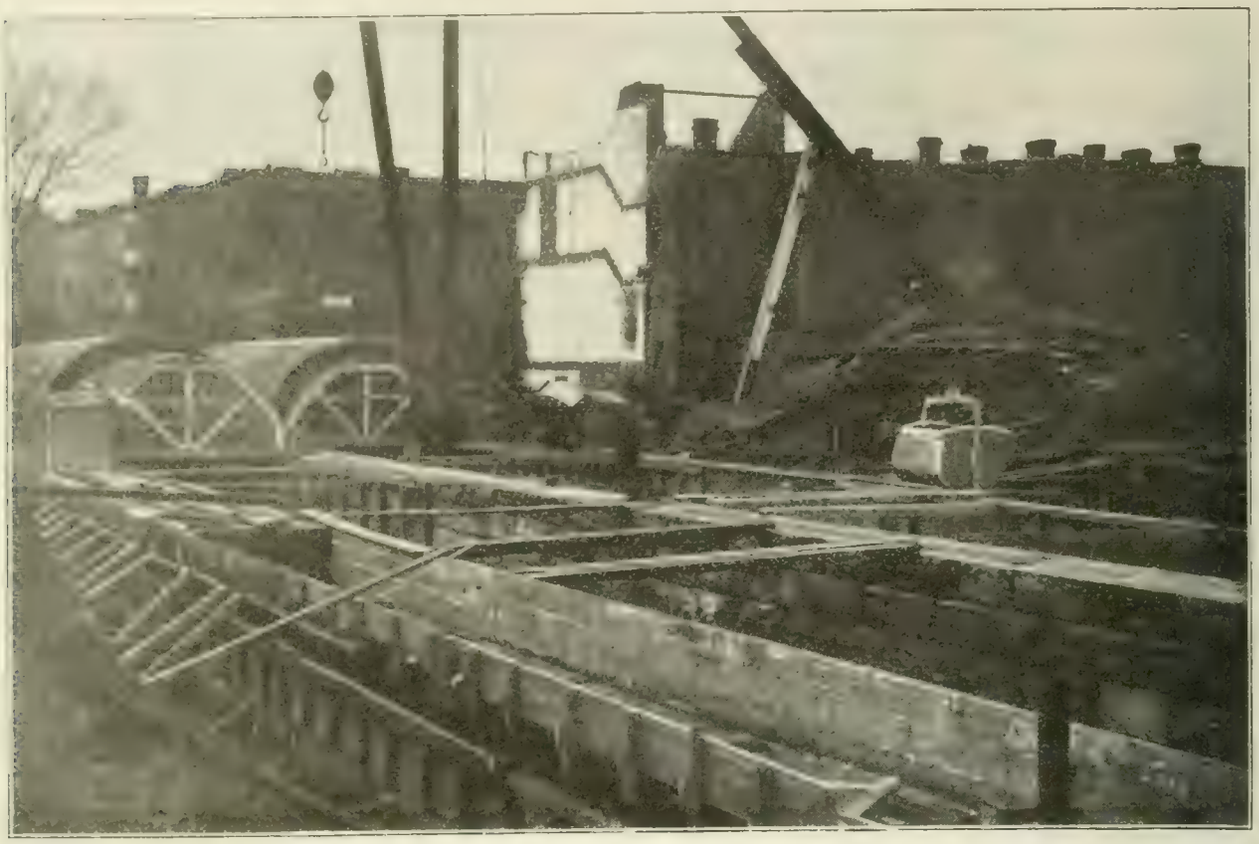
When the loaded buckets travel down grade, and the difference in elevation is sufficient, the tramway may be made to operate by the force of gravity. If this is not the case, power can be applied by means of bevel gearing attached to the terminal shaft and operated by a steam engine, motor, water wheel, or other source of power. The standing track ropes, upon entering the upper terminal, are anchored to special fastenings. An overhead rail connects both standing ropes, allowing the buckets to travel over this rail from one track cable to the other. By means of a patented lever device, the speed of all incoming carriers, after be-

Trust

BUILD a little fence of trust
Around to-day;
Fill the space with loving work,
And therein stay;
Look not through the sheltering bars
Upon to-morrow;
God will help thee bear what comes,
Of joy or sorrow.

—Mary [illegible]

NORTH END OF DOUBLE PASSENGER TUNNEL, SHOWING CONCRETE RETAINING WALLS.
All to be covered deeply with dirt.



The Washington Union Station

Fifteen Million Dollars being Spent in its Construction and Approaches

By M. G. ELLIOTT

WASHINGTON is justly termed a beautiful city. It is a place of residences and fine public buildings, with no factories or large commercial houses to create grime and business rush. Yet, with but few exceptions, there are no magnificent buildings outside of those erected by the Government. The new Union Station, however, will constitute one private enterprise of which any city may be proud. On this work, millions are being spent where hundreds of thousands would be deemed sufficient in other cities of Washington's size. Considerable preliminary work has already been done; but the present condition of upheaval and apparent confusion at the station's site and its approaches is so great that the stranger is utterly unable to make head or tail of the general scheme of improvement.

The first work has been the moving of great masses of dirt. The new station will rest upon made ground where the roofs of full two-story dwellings recently stood. There is now present to the eye, near the Capitol, an immense fill of yellow dirt. But this fill, which has been hauled from the site of the new office building of the House of Representatives, by the little dinky engines, puffing and blowing in front of the Capitol building, represents only in a small degree the huge task of raising the vicinity of the new Union Station to the elevation contemplated by the engineers. Some idea of the size of the task may be had from the accompanying illustrations, one of which shows a sewer column rising in the middle of one of the streets near the Capitol, and another a column situated on the edge of what will be the new plaza. These rise to a height of some 25 and 35 feet respectively. Strangers and even residents of the city have

been puzzled to account for these tall, tower-like columns rising in the center of a thoroughfare. The columns are capped with ordinary iron manholes, the top surface of which represents the new level of the streets which will radiate in all directions from the grand plaza in front of the station.

A Giant Earth-Fill

The elevation of the floor of the station is to be 58 feet above mean tide water, while the elevation of the lowest ground to be filled in is only 20 feet above tide; this gives some idea of the amount of fill necessary to meet the new level. Nearly 1,000,000 cubic yards of earth will be required to form the new plaza, the fill of a considerable area being 35 feet. The estimated expense of the undertaking—which falls jointly upon the United States Government and the District of Columbia—is $1,600,000.

This filling is in reality nothing more than a continuation of the hill upon which the Capitol stands, the ground elevation being at that point 87.2 feet, while in the vicinity of the station this now slopes away to 30 feet, and forms an abrupt slope at that. The locality is a natural hollow, once the home of the marsh folk. The old Tiber creek ran through this section; and, as it had little or no current, the inhabitants of the neighborhood were subject to all the ills of malaria, typhoid,

Sewer Manhole 25 Feet above Present Street Level.

Sewer Manhole 35 Feet above Present Street Level, Showing the necessary "fill" to avoid the steep [illegible] of the plaza

and like diseases. During the mayoralty of "Boss" Shepherd and others of the enterprising builders of Washington of years gone by, the course of the creek was obliterated; yet this section is still and will probably for some years to come be known among the small boys of Washington as "Swamp-poodle."

The amount of earth removal required by this gigantic railroad improvement from beginning to end, is almost beyond conception. Out in south Brookland, a suburb, in order to bring the roadbed to the proper grade, an immense hill has been transported nearly a mile to fill in a sunken section; and in grading for the railroad yard in Eckington, a suburb now within city limits, the earth removal, nearly 1,000,000 cubic yards, will be utilized in filling for the foundation of the terminal.

Two Spacious Tunnels

To the south of the station, two large tunnels are now in course of construction. One, a double-track affair, which is being built by the "cut-and-cover" method, will be used solely for freight traffic.

When the original bill for the construction of the new station, terminal, and tunnel was being framed, the idea

of the railroads, supported by a number of Senators and Members, was to construct a tunnel directly under the enormous stone mass of the Capitol itself, with an underground sub-station into which the Senate and House elevators could conveniently run. Thus statesmen, hurrying to the repairing of political fences, could pass from the legislative chambers, seize their suit cases, enter the Capitol elevators, step from them into a Pullman, and be whisked to the four corners of the country, without once exposing themselves to the dangers of the open air. It was explained that as an engineering feat this was entirely practicable; but it was also remarked that the plan would practically turn the United States legislative halls into a railroad station; and the project was very wisely abandoned.

SOUTH PORTALS OF THE PASSENGER TUNNELS.

The second of the tunnels above mentioned, itself a double tunnel, however, passes beneath Capitol Hill between the Capitol building and the new Congressional Library, and will be used for passenger traffic alone, all trains from the south finding entrance by way of a new steel bridge over the Potomac which has recently superseded the old Long Bridge, a famous landmark of the McClellan and other campaigns of the great war. This passenger tunnel, from the southern approach to Capitol Hill up to the House of Representatives office building site, has been constructed by the cut-and-cover method; from this point until within a distance of 525 feet of the new station, the tunneling will be by the boring method. The contractors desired to build this section also by the cut-and-cover method; but the authorities at the Capitol objected, as the work would disfigure the Capitol grounds, tearing up walks, walls, and even some of the historic trees of the city. This tunnel will be about 4,000 feet long, and will have a height of 17 feet from rail to soffit of arch. Where it passes under Capitol Hill between the Capitol and the Library, the base of the rail will be sixty feet beneath the street surface. The spoil from this tunnel is hauled away by means of a narrow-gauge road, the cars being drawn by electric mine locomotives a short distance and then dumped into cars of ordinary size. A mile away, this earth is used in filling the approach to the new Potomac bridge.

While legislators may not pass from the halls of Congress directly into Pullmans, nevertheless, when this tunnel is

EXCAVATION FOR SUBTERRANEAN STATION.
At site of proposed House of Representatives office building.

completed, a branch line will be run into the basement of the new Congressional office building, which will enable them to connect very closely between their offices and trains. Access between this office building and the Capitol will be afforded by a second tunnel, which will in fact be merely a long underground corridor with handsome illuminations, frescoings, paintings, and decorations.

The new Union Station itself will front on a grand plaza 500 feet wide by about 1,000 feet long, decorated with artistic balustrades, terraces, and fountains. Nine streets will lead into the plaza, which itself will provide a space for massing troops and spectators for public ceremonies.

All in all, about $15,000,000 is being expended in this work in the District of Columbia. Finished, the roads will be in such a condition that Washington will no longer suffer from the congestion of traffic so often noticed when hundreds of thousands of strangers visit the National Capital to witness the inaugural ceremonies and other gatherings for which the city is famed.

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¶ Keep busy.

¶ Don't half-do things.

¶ Delays are dangerous.

¶ The key to success is not the night-key.

¶ Some men are too slow to get out of their own way.

¶ Not he who has little, but he who wants more, is poor.

¶ You can lead a boy to college, but you cannot make him think.

¶ A man may have more money than brains without having an overplus of either.

¶ Most of us have trusted to luck so often that there ought to be a good deal owing to us.

¶ The men who have lifted the world have never been too great to touch it with their hands.

¶ Opportunity is a visitor who should be made welcome without regard to circumstances.

¶ Many a man chivalrously shouts of woman "God bless her!" but fails to bless her himself.

¶ Occasionally a man earns a living without getting it, but more often he manages to get a living without earning it.

The Era of Tunnel Building

WITHIN the last few years the amount of tunnel building in the vicinity of New York City has reached very large proportions; and whereas the lower part of Manhattan Island was accessible, from the Long Island and New Jersey shores, only by means of ferries, with the exception of the Brooklyn Bridge, now tunnels are completed or in course of construction which will afford numerous connections with the localities mentioned. The importance of this work can hardly be overestimated when we consider the thousands of people who travel daily to and from the business section of Manhattan; and elsewhere in this issue will be found an interesting account of how this work of tunneling is being prosecuted.

From an engineering standpoint, the features of greatest interest in this work, are the new methods which have been devised for the borings, and the speed with which the work is being carried out. It was not until 1889 that the modern shield method was employed, and the Hudson River tunnel from Jersey City was the first large tunnel in which the use of compressed air was employed. This made feasible work which was otherwise entirely impossible, and notably decreased the danger to the life of the workmen in the tunnel. In some of the older tunnels, twelve to fifteen years, or more, were spent on the work, which was almost always accompanied with numerous fatalities to the workmen. In the New York and other modern tunnels, the duration of the work has been measured by months instead of years; and up to the present time it has been carried on with remarkable immunity from accidents.

Electricity in Agriculture

THE use of electricity in agriculture has been a favorite theme for speculation ever since the distribution of current for lighting and power became common. A few desultory experiments have been reported from time to time, some of which, it was claimed, had accomplished marvelous results in accelerating the growth and increasing the size of plants electrically treated, but very little really reliable information in regard to this subject has heretofore been available. It will therefore be of interest to learn of the tests in electroculture now being undertaken by a branch of the United States Department of Agriculture, which are described elsewhere in this issue.

The earliest experiments in this direction consisted in growing plants under an electric light with the idea of forcing the growth by keeping them in the light constantly. There is probably little or no advantage to the plants in this treatment; and even if a decided advantage could be shown, the improvement would be entirely incommensurate with the cost of applying the electric light.

The experiment of passing a current through the soil in which plants are growing has often been tried, although generally in a rather unsystematic manner; and, while good results have unquestionably been obtained in forcing plants in this way, no systematic records of these results are available. For this reason, the tests of the Department of Agriculture will be the first authoritative information on this subject.

Whatever may be the results of electrical treatment, it would appear that the cost of such an advanced method of farming must limit it to the laboratory, especially if central station current must be bought for the purpose. The early maturity and increased yield of a general crop must be extremely marked to pay for the application of current at a cost of five cents, more or less, per kilowatt-hour, if the application of electricity is to be continued for any great length of time. If, however, the current could be generated by wind or water power, without too great an initial investment, electriculture might become practicable on a large scale in such cases. Moreover, an economical current supply on a farm could be used in many ways—for the operation of farm machinery, dairy machinery, lighting of buildings, etc.

Vacuum-Tube Electric Lighting

ON another page is given a description of the Moore system of vacuum-tube lighting, which in several particulars varies very materially from all other systems of electric lighting that have reached the stage of commercial application. This system consists, in brief, of a long tube of light, in color and diffusion closely resembling daylight; and this tube can be shaped so as to follow the architectural lines of a room or building. The life of this light is as yet uncertain, but it has been maintained for over two thousand hours without apparent deterioration, and at the end of this time its initial efficiency was unchanged. Its efficiency, in its present state of development, is about 2.6 watts per candle-power. The simplicity of this system, its high efficiency, and its long life point to its commercial success, although, like all new inventions, only the test of time can determine its ultimate value.

The ideal light is a light without heat—that is, one in which the energy consumed is all utilized as light, and none of it as heat. The incandescent lamp, which is in general use for interior illumination, converts but a very small percentage of the electrical energy absorbed into light, the rest being dissipated as heat. The arc lamp is considerably more efficient, but is not well adapted to interior illumination except in very large rooms. The efficiency of the incandescent lamp varies from 3.1 to 3.5 watts per candle-power when the lamp is new; but this drops to 5 or 6 watts per candle-power after a lamp has burned for some length of time. In other words, one electrical horse-power is required for about fifteen new 16-candle-power lamps, or a total of 240 candle-power. But after burning from 500 to 600 hours, these lamps will lose about 20 per cent in candle-power and should then be renewed.

If continued in use until they burn out, they may last for perhaps 1,500 hours; but during the latter half of their life, the candle-power will have fallen off from 30 to 40 per cent. Of course, an incandescent lamp may be burned at a much higher initial efficiency—say 2½ watts per candle-power; but in this case its life will be reduced to 150 hours or less.

The matters of efficiency and life decide the cost of any system of lighting; and it is in these respects that a vacuum-tube system has a great advantage over the incandescent-lamp system. The reason for this is that the gas in the former system can be raised to a much higher temperature without destructive effects, than the carbon of the latter system; and in the tube system a greater proportion of the energy is utilized as light, and less is wasted as heat.

The term "vacuum tube" is really a misnomer, for the tubes contain a more or less attenuated gas; and it would seem that there might be considerable difficulty in maintaining an extensive system of tubes without leakage. This, however, is a mechanical detail, which apparently has been successfully overcome. The so-called vacuum-tube system offers a very promising field for the attainment of great improvement and economy in artificial illumination.

Business Engineering

IN this issue will be found a timely and interesting article, by Mr. Henry F. Ballantyne, on "Cost in Engineering Work," which touches on an aspect of engineering that is prone to be neglected or to be too lightly thought of, especially by the young engineer. The question of cost is, perhaps, not a vital one to the engineer engaged in purely scientific work, such as laboratory experiments in investigation of new theories, discoveries, etc.; but by far the greater portion of engineering work of to-day is connected with commercial enterprises, and in these the cost is almost always the governing factor.

In the design of a plant for the manufacture of any line of goods, a complete estimate of the first cost of the plant, as well as a very careful analysis of the cost of its operation, must be the first work of the consulting engineer. The amount and selling price of the goods produced can be estimated very closely, so that the income of the plant is known approximately. There are, then, two main factors of cost to be determined—the cost of installation and the cost of operation; and both of these must be in proper relation to the value of the output. There is in most lines of manufacture a pretty definite proportion between selling price and factory cost, and the plant must be designed so that the latter shall come within an amount upon which a reasonable profit can be made.

The total cost of the plant constitutes the initial investment; and, as plants are frequently built with borrowed money, the interest on the investment is a fixed charge which must be met. The operating expenses are sometimes difficult to fix, but they can be determined pretty accurately from the design of the plant. These include the cost of coal, water, labor, raw material, maintenance, depreciation, rent, taxes, etc., which amounts, together with the fixed charges, determine the factory cost. Too much care cannot be given to this estimate, for the neglect of any one item may mean failure of the plant commercially.

There are many plants which start up with apparently excellent prospects for profits, and which seem for a while to be running profitably; but after a few years the machinery begins to wear out, breakdowns occur, and the output is reduced in quantity or quality because the items of renewals and depreciation have been neglected or underestimated. The owners of the plant are then faced with the necessity of investing new capital to put the plant in order again, and this means an increase in fixed charges and a corresponding reduction in profits.

For these reasons, the successful engineer must be a good financial as well as technical man. The main object of engineering enterprise in connection with industrial work is economy—to reduce the cost of production. And the engineer whose work results in commercial failure to his clients is as much a failure as one whose work is technically unsound.

Wireless Telegraph Outfit

Brief Description of a Simple Apparatus for Experimental Purposes

By Dr. ALFRED GRADENWITZ

A VERY suitable outfit, comprising both sending and receiving apparatus, for generating electric waves, demonstrating the distance effects of the latter, and such interesting electrical resonance phenomena as are being made use of in wireless telegraphy for tuning the sender and receiver, both in themselves and with regard to one another, has been designed by Herr E. Ruhmer, of Berlin, Germany.

The sender, which is represented in Fig. 1, comprises: (1) A high-tension condenser enclosed in a polished mahogany wood box; (2) an adjustable spark gap, consisting of two zinc rods, which are fitted in a micanite cylinder to eliminate any luminous and acoustical effects of the spark discharges; (3) a self-induction coil susceptible of regulation, wound on a slotted hard rubber cylinder and free to rotate on the foundation box; (4) any desired number of resonance coils, wound on hard rubber tubes; and (5) an antenna formed by two brass tubes, slipped one over the other, terminating in a sphere.

The connections of the various parts are shown schematically in Fig. 2, after 180° rotation. If the two terminals placed in parallel to the spark gap be connected to a high-tension transformer in order to charge the condenser, an oscillatory discharge in the primary closed vibration circuit will be produced in the time $T = 2\pi\sqrt{C \times L}$, in which C is the capacity, and L the adjustable self-induction of the primary. As inferred from this formula, the period may be varied by altering either the capacity or the self-induction, the latter method being resorted to in the present case. To this effect, the self-induction coil is made from bare copper wire, wound in the slots of the hard rubber cylinder, which is made to rotate by means of a spring pulley and crank. By the aid of a sliding contact running in parallel to the hard rubber cylinder, any desired number of windings may be inserted (turning the crank visible in Fig. 1 to the right of the foundation box). Now, if any one of the resonance coils with antenna be inserted in the apparatus, while one of the termi-

nals of the spark gap is being earthed, it will be easy by turning the crank round to find the position of the self-induction coil with which the primary closed vibration circuit is tuned to the secondary open vibration circuit, comprising a self-induction (resonance coil) and capacity (antenna). In virtue of the stationary waves then formed in the resonance coil, strong radiations of high-tension electricity corresponding to a node of the coil (which vibrates in one-quarter wave-length) will be obtained from the upper end of the resonance coil. The product of self-induction and capacity will be the same in the two coupled circuits. As soon as the primary self-induction is altered by an addition

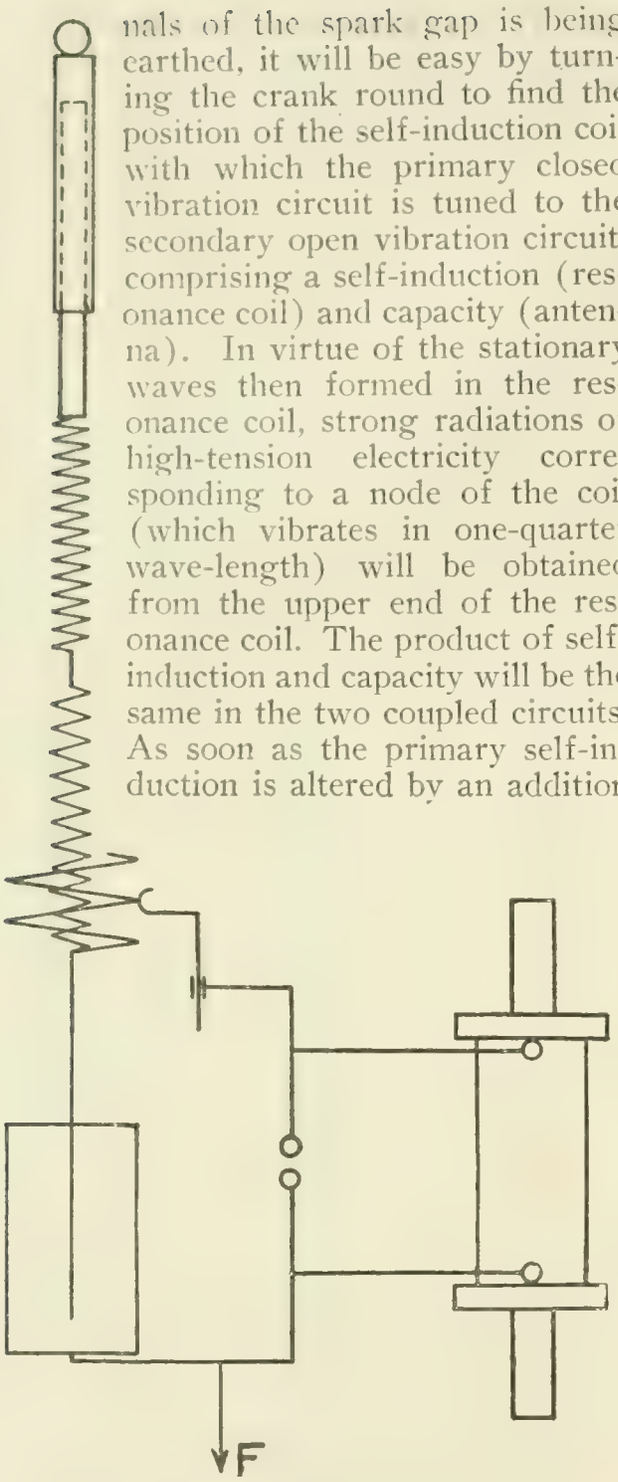


Fig. 2. Connections of Sending Apparatus.

or elimination of exciter windings, all radiations will be discontinued.

It is also possible to tune the secondary vibration circuit to the primary by altering the capacity, and accordingly the proper vibration of the secondary circuit, shifting for this purpose the two sliding tubes that constitute the antenna.

For demonstrating the distance effects of the electric waves given off by this sending apparatus, a receiving device is used, which consists mainly of one or of two resonance coils, the lower ends of which are metallically connected to the earth. The receiving system is tuned either by shifting the antenna tubes, or by means of a hard rubber ring containing a sliding contact and sliding over part of the resonance coil, which is wound with bare wire.

After tuning the sending apparatus in itself, the mutual tuning of the sender and receiver to the same wave-length is obtained by shifting the sliding contact over the bare wire coil, or by altering the

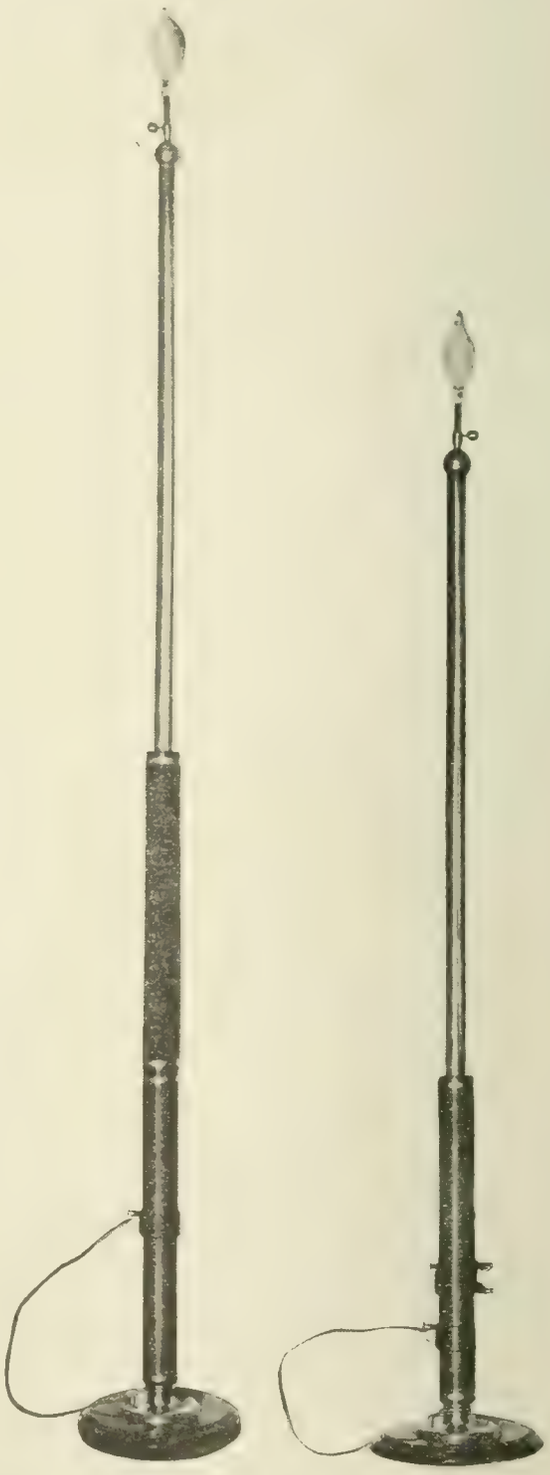


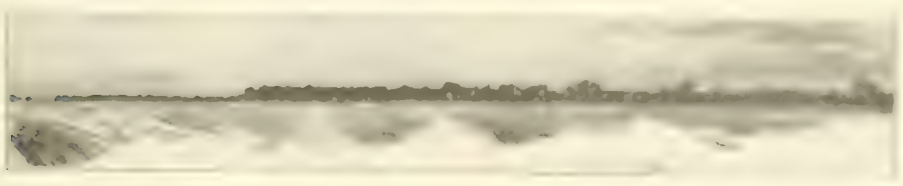
Fig. 3. Fig. 4.

Two Forms of Electric Lamp Used as Wave Detectors.

length of antenna, when distinctly perceptible radiations will be obtained from the upper end of the coil or antenna of the receiving apparatus.

For detecting the waves, two electric lamps are used. One of these is a Geissler tube, responding to tensions and being arranged like a coherer in a tension node—that is, on the antenna (Fig. 3). There is moreover used a small electric glow lamp inserted in a [illegible] current intensity, as wave detector corresponding to current intensities in a tension analogous to an electrolytic cell (see Fig. 4).

The above apparatus is especially suitable for demonstrating the principles of wireless telegraphy.



Measurement of Currents

Various Methods of Determining the Flow of Streams

By PAUL ARR

THREE methods are employed in measuring the flow of water. These are known as the Weir Dam method, the Miner's Inch method, and the method of measurement by Cross-Section and Velocity. The Weir Dam method is the most accurate and reliable, and should always be employed for close calculations. The Miner's Inch method is of California origin, and is not used anywhere except on the Pacific coast. It is a method adopted by the various irrigation ditch companies in disposing of water to their consumers. It is sometimes desired to determine the quantity of water only approximately—in which case the method known as measurement by Cross-Section and Velocity is used.

Cross-Section and Velocity Method

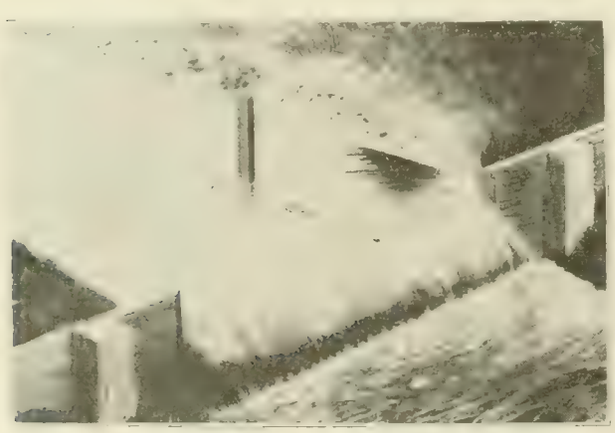
To measure water by the latter method, select a stretch on the stream or the ditch which will afford as straight and uniform a course as possible. If the water is at any point carried in a flume, it is better to measure at this point. Lay off a distance of, say, 300 feet; measure the width of flowing water at about six different places in this distance, and obtain the average width; likewise at these same points measure the depth of water at three or four places across the stream, and obtain the average depth. Next, drop a float in the water, noting the number of seconds it takes to travel the given distance. From this can be calculated the velocity of the water in feet per second. The quantity of the flow can then be determined by multiplying the average width (in feet) by the average depth (in feet) by the *velocity* (in feet per second). This will give roughly the flow of the stream in cubic feet per second. From the figures so obtained, it is advisable to deduct about 20 per cent, as the surface velocity of the water is in excess of the actual average velocity.

MEASURING FLOW BY METHOD OF CROSS-SECTION AND VELOCITY.

When the stream is of sufficient depth —say three feet or over—the average velocity can be more closely determined by using a pole, to one end of which is attached a stone or piece of lead of sufficient weight to cause the pole to sink nearly to the bottom. In this way the velocities at the surface and bottom of the stream counteract each other, and a closer approximation of the average velocity is obtained.

Weir Dam Method

Following is the method pursued in measuring by the Weir Dam system:— Place a board or plank in the stream, as illustrated, at some point which will allow a pond to form above. The board should have a notch cut in it with its edges beveled toward the intake, as shown. The length of the notch should be at least four times its depth for small quantities, and longer for large quantities. In addition to the above, for accurate measurements, it is advisable also to have, if possible, the length of the notch about two-thirds the width of the water on the up-stream side: it may be necessary to experiment somewhat in order to obtain this condition.



WEIR DAM METHOD OF MEASUREMENT.

The overfall, or vertical distance the water falls on the down-stream side, should be about twice its depth—that is, twelve inches if the notch is six inches deep; and so on.

In the bed of the pond, not less than three feet, and preferably six feet, from the weir, drive a stake near the bank, with its top precisely level with the bottom of the notch in the weir; then measure carefully with a rule the depth of water over the top of the stake. This will give the theoretical depth of flow corresponding to that of the table (see accompanying table for use in measurements).

In order to obtain accurate results, it is essential that the velocity of water in the pond be extremely low; and if the weir be constructed of proper proportions, this condition will exist.

Table for Weir Measurement

Giving cubic feet of water per minute flowing over a weir one inch wide and ⅛ inch to 20⅞ inches deep

Inches	⅛	¼	⅜	½	⅝	¾	⅞
0	.09	.22	.37	.58	.14	.19	.26
1	.33	.47	.65	.83	.03	.24	1.05
2	1.11	1.30	1.50	1.70	1.91	2.13	2.36
3	2.60	2.85	3.11	3.38	3.65	3.94	4.23
4	4.53	4.84	5.16	5.48	5.81	6.15	6.50
5	6.85	7.21	7.58	7.96	8.35	8.75	9.16
6	9.58	10.01	10.44	10.88	11.33	11.79	12.26
7	12.74	13.23	13.73	14.24	14.76	15.29	15.83
8	16.38	16.94	17.51	18.09	18.68	19.28	19.89
9	20.51	21.14	21.78	22.43	23.09	23.76	24.44
10	25.13	25.83	26.54	27.26	27.99	28.73	29.48
11	30.24	31.01	31.79	32.58	33.38	34.19	35.01
12	35.84	36.68	37.53	38.39	39.26	40.14	41.03
13	41.93	42.84	43.76	44.69	45.63	46.58	47.54
14	48.51	49.49	50.48	51.48	52.49	53.51	54.54
15	55.58	56.63	57.69	58.76	59.84	60.93	62.03
16	63.14	64.26	65.39	66.53	67.68	68.84	70.01
17	71.19	72.38	73.58	74.79	76.01	77.24	78.48
18	79.73	80.99	82.26	83.54	84.83	86.13	87.44
19	88.76	90.09	91.43	92.78	94.14	95.51	96.89
20	98.28	99.68	101.09	102.51	103.94	105.38	106.83

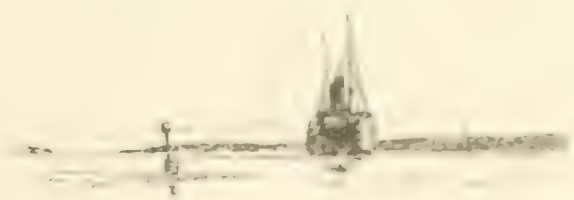
Example Showing Application of Above Table

Suppose the weir to be 66 inches long, and the depth of water on it to be 11⅝ inches. Follow down the left hand column of the figures in the table until you come to 11 inches. Then run across the table on a line with the 11, until under ⅝ on top line, and you will find 15.85. This, multiplied by 66, the length of weir, gives 1,046.10, the number of cubic feet of water passing per minute.

Miner's Inch Measurement Box

Miner's Inch Method

The term "Miner's Inch Method" is more or less indefinite, for the reason that the water companies, in measuring water used by their customers, do not all use the same head above the center of the aperture and the so-called "inch," accordingly, varies from 1.50 to 1.75 cubic feet per minute. The most common measurement, however, is through an aperture two inches high and of whatever width may be necessary, through a plank 1¼ inches thick, as shown in the illustration. The lower edge of the aperture should be two inches above the bottom of the measuring box, and the plank five inches high above the aperture, thus making a six-inch head above the center of the stream. Each square inch of this opening represents a "miner's inch," which is equal to a flow of 1½ cubic feet per minute. The element of time is not considered in the calculation of a miner's inch.



WHERE HISTORY

MINUTE MAN STATUE AT CONCORD, MASSACHUSETTS.

This monument stands near the famous North Bridge that figured so prominently in the historic battle, or rather skirmish, of April 19, 1775, which, in conjunction with the earlier engagement of the same day at Lexington, began the War of the Revolution. When the 800 British soldiers under Lieutenant-Colonel Smith and Major Pitcairn, who had been detailed by General Gage to destroy the stores at Concord, arrived at Concord, they found an armed force of 300 Provincial troops, under Colonel Barrett and Major Buttrick, ready to receive them. In the fusillade that followed, several on both sides were killed and wounded. After setting fire to the courthouse and destroying some stores, the British retreated toward Boston. They were saved from capture only by a reinforcement of 900 troops, who joined them at Lexington, in spite of whose assistance they were so harassed by the Provincials along the route that their retreat became a rout.

WAS MADE

Leyden Street, North, Plymouth, Mass. It follows closely the lines of the first street laid out in Plymouth—a path running from the Pilgrim spring to the top of the hill where the fort stood.

Site of first permanent Swedish settlement in America. This stone is a portion of the rocks on which the first Swedish colonists landed under Peter Minuit, March 29, 1638, and marks the site of old Fort Christina, at the mouth of the creek of that name on the Delaware coast. New Sweden, as the colony was called, passed by conquest to the Dutch in 1655, and to the English in 1664. Memorial erected by Delaware Society of Colonial Dames of America, March 29, 1903.

Life Stories of Successful Men

Frederick Douglass Underwood

By HENRY M. HYDE

Author of "The Buccaneers"

IT would be possible to get a fairly good idea of the character and career of Frederick D. Underwood by simply studying his photograph.* The face is that of a man accustomed to the handling of large responsibilities, self-reliant and determined, trained to meet emergencies and to handle men.

First a clerk, then a brakeman on the Chicago, Milwaukee & St. Paul road in 1870; President of the great Erie Railroad System in 1901—that is the beginning and the end of his story. Between it lies a record of hard, conscientious work, of steady climbing, of constant growth in capacity, which cannot fail to prove inspiring to the American boy who is ambitious to rise in the railroad business, and who starts, as did he, with no advantages save those of good health, native ability, and bull-dog determination to "get on."

Though the president of one of the greatest of Eastern railroad systems, Mr. Underwood is of the West, Western. He belongs to that large and exceedingly important class of Eastern railroad executives who received their early training in the freer and less formal air of the Middle and Far West. Strangely enough, it may be remarked in passing, there is no Western railroad president who came to his position from an Eastern training and who has made a great success in his new post.

Mr. Underwood was born in the little Wisconsin village of Wauwatosa, fifty-three years ago. He went to the public schools of his native town, and a little later attended the fine old Wayland Academy at Beaver Dam, Wisconsin. At eighteen he was ready to go to work. From the very first he showed one of those qualities which have since proved factors in his success. Although he had an academic education, he did not feel himself above settling down to hard manual labor. The railroad business appealed to him, and he began to learn it at the bottom, starting as brakeman on a local run. That was on the old Chicago, Milwaukee & St. Paul Railway, in the service of which he remained for eighteen years. During that time it would be hard to name a position on the operating side of the road which Mr. Underwood did not fill—from twisting a brake wheel up to superintending a division. He served as superintendent of elevators, as train master, and in half a dozen other capacities from the one post to the other.

The Chicago, Milwaukee & St. Paul road was Mr. Underwood's *alma mater* in the railroad business. When he left it to assume larger responsibilities, he knew the business literally from the ground up. There was nothing in the operating department of a railroad of which he was not master. Eighteen years is a long apprenticeship for an ambitious young man to serve in any business. It makes the four-year period spent in preparation by a professional man seem trivial in comparison. But that it was well spent and was well worth spending, Mr. Underwood's subsequent career has sufficiently demonstrated.

When he left the St. Paul to take the position of General Superintendent of the Minneapolis & Pacific Railway in 1886, Mr. Underwood took with him two qualities which have ever since been especially valuable to him. One was an ability to meet any crisis in the operating of a railroad, quickly and successfully. That was a direct result of his practical acquaintance with every detail of railroad operation. When an accident happened, Mr. Under-

*NOTE.—Mr. Underwood's portrait forms the frontispiece in this number.

wood was always quick to understand its causes, and to decide what were the steps necessary to be taken. His long training had made him resourceful; it is said of him that never has he been cornered.

The second great quality is that of always keeping in touch with the working force under him. It is easy to understand that an executive who has himself served as a brakeman will be quicker to understand and sympathize with brakemen, than will one whose knowledge of that part of the work is purely theoretical. This quality has enabled Mr. Underwood to develop among the operating force of every road with which he has been connected a splendid *esprit de corps* — the spirit of loyalty and enthusiasm.

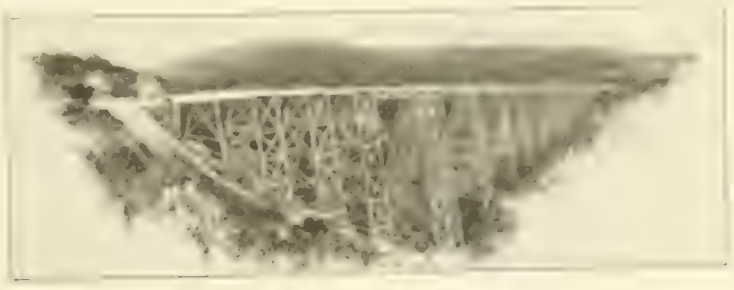
Nothing is more important to the success of any large enterprise. When employees, even down to the most minor, speak of "our road" and know that its president is always ready to hear their troubles and complaints, the battle has been half won. On a great system employing thousands of men, such a general feeling is one of the most valuable of assets. The man who can inspire and maintain it is hard to find; and, once found, railroad owners will hold him at almost any cost.

The third in the trinity of great qualities which have made Mr. Underwood one of the foremost of railroad managers, is that of a tireless personal energy. His associates speak of him as a perfect whirlwind of determination and action. Like every railroad president, he carries responsibilities which would quickly crush a man less thoroughly trained—less hardened to the constant strain.

In 1880 Mr. Underwood was called to take charge of the construction of the Minneapolis, St. Paul & Sault Ste. Marie Railway, and conservative of its operation. He retained the position of General Manager of that road for thirteen years, which covered the period from the time the first rail was laid until 1893. Upon leaving the service of that railway, his work there was epitomized in the following resolution of its Board of Directors:

"He carried with the Company's name to an infancy, and he leaves it with [illegible] well-constructed and thoroughly equipped railway, a successful operation, with all promise for results, created largely through the energy, ability, and wisdom of his management."

In January, 1899, he went to the Baltimore & Ohio as General Manager. In June, 1899, he was promoted to Second Vice-President. In May, 1901, he was called to the presidency of the great Erie Railroad and its allied companies. In that capacity he has since served, ranking among the ten or a dozen great railroad managers who to-day have practically the whole transportation interests of the country under their direct charge.



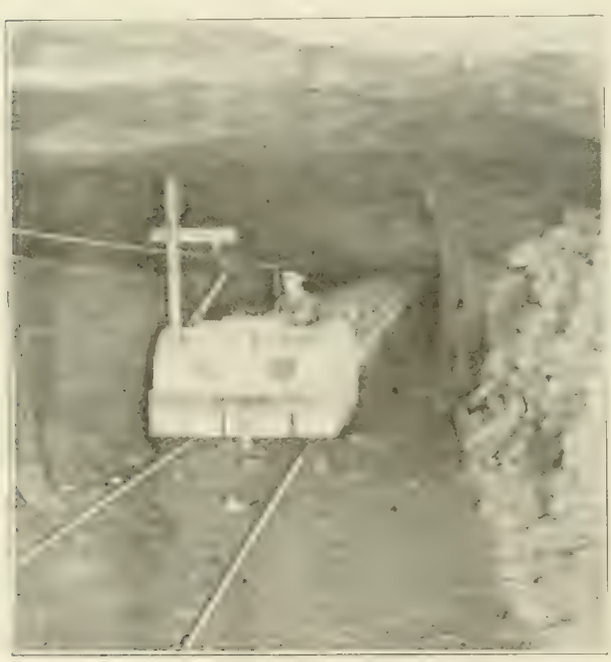
A 10-TON ELECTRIC LOCOMOTIVE HAULING TRAIN-LOAD OF COAL ON GRADE.

Railroading Below Ground

The Subterranean World of the Mines Invaded by the Electric Locomotive, Lessening Danger and Lightening Labor

By R. REFORD

ELECTRIC locomotives have brought about a new era in mining. Now they may be found speeding about in tunnels far below the surface of the earth, at depths whereat it has heretofore been impossible to operate any kind of haulage system. In their case there is no smoke to choke up the subterranean passages; and with their cleanliness and freedom from the many faults common to other kinds of haulage engines, these types of locomotives permit of convenience, economy, and absolute safety at almost any depth underground to which it is possible for man to penetrate. No fires need be built in running them, and thus the danger of igniting the explosive gases that sometimes form in mines is avoided. They go down into the deepest mines, bring out their trains of coal or ore, and haul them directly to the dock or smelter. They make their way into the mountain side, and haul away the raw material to the point of shipment or to other places desired, with greater speed and economy of operation than was ever before known. They work as well in the deep, damp, and dark depths as they do on the surface of the earth. They are always in readiness for operation, and can be started or stopped with the promptitude of a trolley car or automobile.



A 15-TON ELECTRIC LOCOMOTIVE HAULING TRAIN OF COAL CARS IN TUNNEL.

In fact, some of these great locomotives that have been constructed for mining purposes might be called underground automobiles. They do not use gas for fuel, however, for that would

be unsatisfactory and dangerous. They are storage-battery electric "automobiles," that haul trains and run on tracks.

In storage-battery locomotives for mine haulage, two general types are used. For mines having ample height of entry the battery is supported directly on the frame of the locomotive, thus adding its weight to that of the locomotive in securing tractive effort on the rails. For low-vein mines the battery is carried on a separate truck or tender, thus reducing the height of the locomotive to a minimum. This arrangement reduces the useful hauling capacity of the locomotive, but accommodates itself to very low entries and rooms, and greatly reduces the amount of stoping which would otherwise be necessary. A still larger type, provided with a cab for the operator, is used in places where it is possible for it to run. This larger type is suitable for switching standard freight cars, and thus, in addition to its service in the mine, is capable of doing duty where conditions prevent the use of a trolley system.

Electric locomotives for mining purposes range in weight from two tons to twenty-five tons. The trolley locomotive is usually built with one, two, or three motors. In the better makes, the entire weight of the locomotive is always used in securing tractive effort on the rails. In the "standard" type, the engineer is seated in the center of the locomotive; the "single-end" type is arranged for the operator to sit at one end; and the "double-end" locomotive is so constructed that the man in control may sit at either end and still have perfect mastery over the engine.

In the "standard," the engineer, seated in the center, is protected from injury by the frame of the locomotive. This construction has frequently saved operators from serious injury and from loss of life, and, when conditions permit, is preferable to those styles in which the operator is seated at the end.

Wire-rope cable railway systems are also used in many mines; but the restrictions on them, and their limited field of operation, make them as inferior to the electric locomotive for general service as is the cable car to the trolley car. For short hauls, however—as in hauling the products of mines to the hoists, to be raised to the surface of the ground—these cable railways are often superior to electric locomotives. This method is known as the "tail-rope" system. The cars are run in trains. They usually weigh about 850 pounds, and hold one ton each. The regular haul of the Coal Valley Company's system at Cable, Ill., is twenty cars.

The tail-rope system consists of two ropes winding on separate drums, which may be located at different points, but which generally work on the same shaft.

A 9-TON ELECTRIC LOCOMOTIVE HAULING TRAIN OF COAL CARS.

The main rope runs along the ground, and is attached to the front of the loaded train. The "tail" rope is supported along the walls of the roof of the tunnel, extending to the end of the haul, where it passes over a return wheel, and is returned along the ground, being attached to the rear of the train. The main rope is then wound on the drum, hauling the load followed by the tail rope. For the return trip, the motion is reversed. The tail rope is wound on its drum, and the empty cars are drawn to the end of the haul, dragging the main rope.

This system is also found in use at enormous depths underground, but usually necessitates the employment of a hoist, while the electric locomotive hauls its cars directly from the mine without change.

Concrete Piling

Its Advantages in Foundation Construction

By PHILIP ARLINGTON

CONCRETE piling, which has been the dream of engineers and builders for generations, is at last coming into practical use. "It is one of the most important improvements in architectural construction ever devised," says one engineer, "and seems destined to revolutionize foundation building."

In a test made in Chicago with a 2,200-pound hammer, dropping 25 feet, it was computed that a 20-foot wooden pile, 10 inches in diameter at the bottom and 12½ inches at the top, would carry 17,000 pounds, or that 10 piles would carry 170,000 pounds; while a 20-foot concrete pile, 6 inches in diameter at the bottom and 20 inches at the top, would carry 65,000 pounds, or five concrete piles would carry 325,000 pounds—a difference of 155,000 pounds in favor of five concrete piles over ten average wooden piles.

BRYSON APARTMENT BUILDING, LAKE AVENUE, CHICAGO, ILL.
Built over 12 years ago, the first building erected on concrete piles.—There has been no settling of its foundation.

Concrete piles can be used in all places where wooden piles can be used, and in some places where wooden piles would be quite impracticable. By their use, permanent instead of temporary struct-

DRIVING A CONCRETE PILE.
The core is shown in the leaders. The shell on the ground is drawn up high enough to be lowered into the shell just driven, and then slipped over the core.

ures are built. They can be used in dry, filled ground as well as in wet soil, which may cause wooden piles to decay. They are adapted to high ground and will prevent any settlement, the settlement all having been made by packing the soil while driving. All soft places, should there be any, will be found. These cannot be discovered in placing ordinary foundations.

A well-known gentleman of Chicago is the inventor of the concrete piles now in general use. Their construction is very simple. A steel pile core, the size and shape of the pile desired, is incased in a thin, closely fitting shell. The core and shell are then driven into the ground in the usual manner by means of a pile driver. By a simple and ingenius device the core is collapsed or shrunken slightly so that it loses contact with the shell and is easily withdrawn, leaving in the ground a clean, perfectly formed hollow tube of the size and depth required. This tube has only to be filled in with the best Portland cement concrete, to complete the pile.

The piles are made in various lengths. In shape they are scientifically correct for the maximum resistance by friction. They taper from 20 inches at the top to 6 inches at the bottom, thus making a symmetrical cone affording a most powerful resistance to soil penetration. This, taken together with the great strength of concrete to resist crushing, and the fact that it is impervious to the ravages of time, decay, and insects, makes an ideal substitute for wood piles and a durable and substantial foundation under all soil conditions.

In some cases it is desirable to drive concrete piles to bedrock, when it is near the surface. For these cases a special core tapering from 20 inches at the top to 13 inches at the point, is used. The piles then form substantial columns of concrete upon which to build the superstructure.

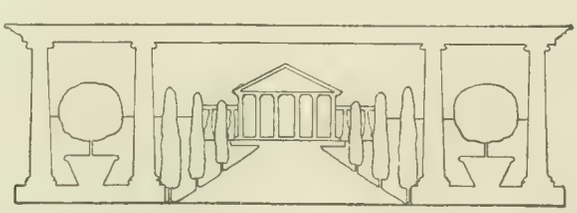
Concrete piles, it is claimed by their manufacturers, are not only much more durable but more economical than

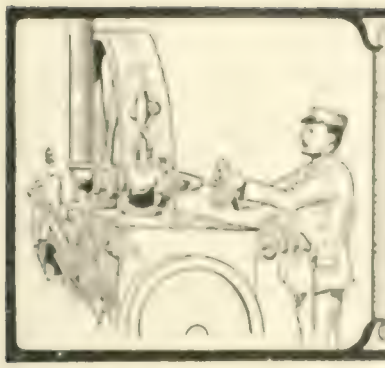
COMPLETED CONCRETE PILES.

The five piles in the center are to carry the chimney.—A comparison with the barrel seen in the picture will give an accurate idea of the size of the piles.

wooden piles, steel beams in concrete, or spread foundations of concrete. As concrete piles are made where they are used, their cost varies, depending upon the cost of transporting the machinery to the site, the availability of material, character of the soil to be penetrated, the number of piles required in a given place, etc. Ordinary wooden piles average about 12 inches in diameter at the top, giving 113 square inches of surface. A concrete pile is 20 inches in diameter at the top, giving 314 square inches of surface, or 2.77 times that of the wooden pile. The taper of the wooden pile is only about three or four inches from top to bottom, while the taper of the concrete pile is 14 inches.

The concrete piles are also especially adapted for trestle work, foundations of abutments and piers, docks, sea walls, wharves, breakwaters, and all other constructions in which a firm adamantine foundation is needed.





ENGINEERING PROGRESS

Sectional Steamboats

A VESSEL that can be "knocked down," shipped on board a transport, and its five sections reassembled again in a seaway, without the aid of divers, all within less than two hours, is a novelty in marine construction now possessed by the United States Army transport service. The vessel is called the *Pontonier*, and its length over all is 80 feet, with 18 feet beam, 3 feet 6 inches draught, and a displacement of 72 tons. Her speed is 11 knots an hour.

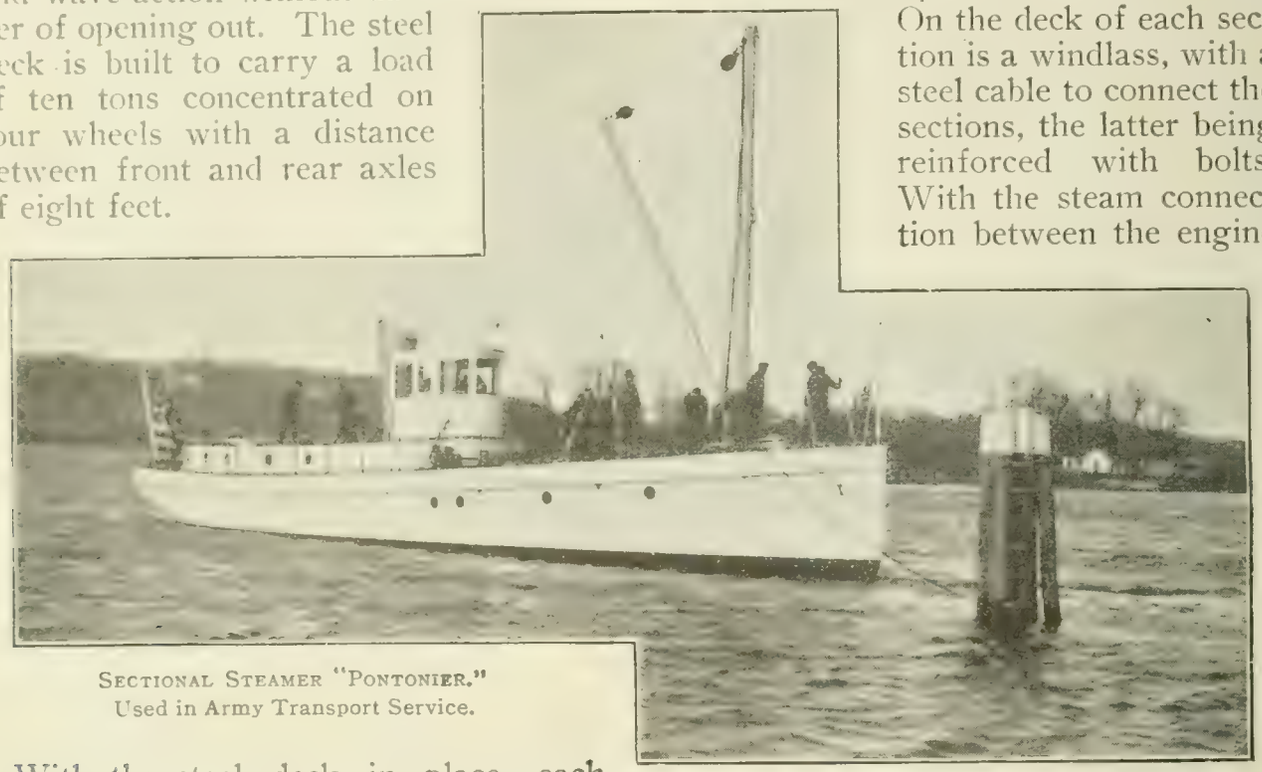
The *Pontonier* is the first vessel of its kind ever constructed, and was designed to meet an experiment which the engineers of the War Department wished to test for general drill and transportation purposes at the United States Engineer School of Application, in Washington, D. C. The service to which the vessel would be put in time of war would be to transport troops and munitions from ships of an expeditionary force to a coast where a landing is to be effected. It is at the present time in active transport service.

The importance of the prompt handling of men, provisions, and war material from army transports, had frequent illustration during the Spanish-American war; and it was the result of lessons gained at that time in landing troops and supplies in Cuba that directed the efforts of army engineers towards an improvement of existing facilities. A craft built in sections so that it could easily be shipped aboard a transport, and as easily floated in sections and reassembled when afloat, was decided on. The sum of $15,000 was appropriated

ASSEMBLING THE SECTIONS OF THE PONTONIER

for an experimental vessel, which was built by the Gas Engine & Power Company, and Charles L. Seabury & Co., Consolidated, of Morris Heights, New York City.

The sectional steamboat is of steel throughout, with a modeled flat-bottomed hull. The assembling parts are arranged so that they can be gotten at readily, and are fitted with a self-locking device, the parts when assembled forming a complete hull which stands running and wave-action without danger of opening out. The steel deck is built to carry a load of ten tons concentrated on four wheels with a distance between front and rear axles of eight feet.



Sectional Steamer "Pontonier."
Used in Army Transport Service.

With the steel deck in place, each member of the vessel becomes watertight, or box-like in form. The bow section carries a derrick and the anchor equipment, with chain and store lockers. The next section aft serves as a hold for the cargo, and also contains quarters for the crew. Twenty men can be berthed. In the third section are the boiler; the coal bunkers, with a capacity of thirteen tons; and a portion of the water storage. On top of the third section is located the pilot house, to the rear of which is provided seating space for passengers. The vessel, however, can be operated without the pilot house. In the section next aft the boiler, is the propelling power—two engines of the double-cylinder compound type, the cylinders being 12 inches and 6 inches in diameter, with 9 inches stroke.

The derrick mast and boom are constructed to lift a weight of six tons, and are provided with hand-hoisting machinery. There are davits for two light boats, and the hatchways into the section of the deck forward are provided with water-tight coverings, which, when down, are flush with the deck. The fifth section comprises the oval counter, which may not be used if so decided.

In assembling the vessel at sea the boiler section is floated first, because of its weight, which establishes the waterline. The sections are fitted with cones 14 inches in diameter. On the deck of each section is a windlass, with a steel cable to connect the sections, the latter being reinforced with bolts. With the steam connection between the engine and the boiler made, and the piping for water feed to the boiler connected to the pump, the boat is ready for service.

The officers' quarters are in the section containing the engines, where a space 11 feet 6 inches fore and aft is cut off with an inside bulkhead for the purpose. The galley is provided with a cooking range, and the cabin and pilot house with suitable seats and tables.

Elevated Railway Fire Cars

FIRE cars on elevated railroads are an innovation recently introduced in Chicago. The cars have proved of great service in extinguishing blazes on and

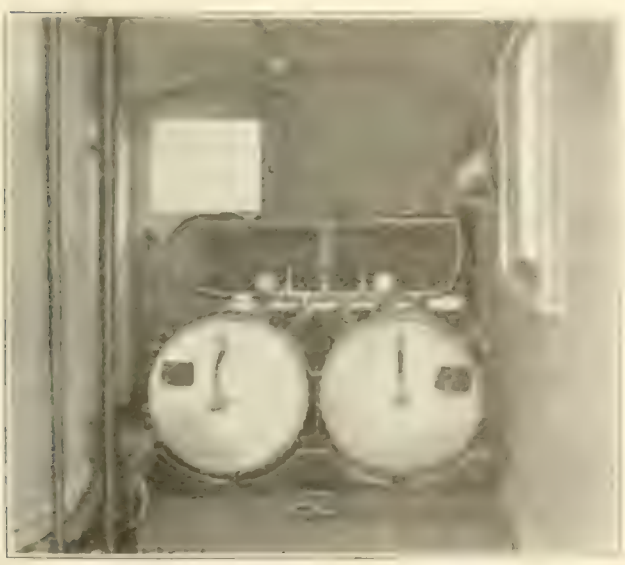
near the tracks, preventing great loss and the blocking of traffic.

The cars correspond in type to the regular chemical engines in use in the city Fire Department. Four of them are stationed at the terminals of the four branches of the Metropolitan Elevated Company's lines.

At a trial given in the presence of members of the Chicago Fire Underwriters' Association and the officials of the railway company at Logan Square, the speed and efficiency of the cars were demonstrated, resulting in their general installation by the road. After a run of one mile, a fire was extinguished within six minutes from the time the alarm was sounded.

The equipment of the fire cars consists of two 100-gallon tanks of chemical solution, and two lines of hose, each 150 feet long. In addition, a reservoir containing 200 additional gallons of solution is carried on each car. A car crew consists of two trained men.

While the fire cars are at present confined to one railway line in Chicago, their success has been so pronounced that they will probably soon be installed by the other elevated systems. Other cities, also, have made inquiries with a view to adopting them. It has been proved that the fire cars can reach a fire on or near the line much more quickly than can an engine of the Fire Department. Because of their running on a track and being propelled by electricity, they are able to

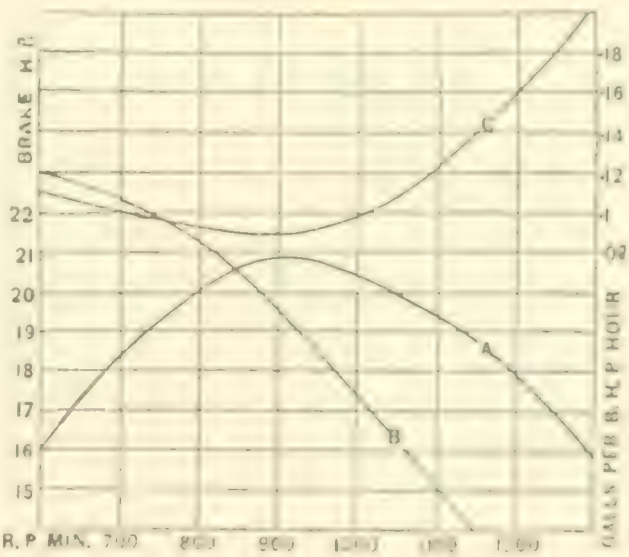


Interior of Fire Car on Elevated Railway.

make many times the speed of the municipal vehicles pulled by horses.

Power of Gasoline Motors

A CONVENIENT rule for finding the approximate horse-power of gasoline motors is: "Square the diameter of one cylinder in centimeters, and divide



by five," for a four-cylinder motor; or, in other words,

$$\frac{(\text{diameter in centimeters})^2 \times 4}{5}$$

For example, take an engine with four cylinders 100 millimeters' bore, and 140 millimeters' stroke. Then, since 1 centimeter = 10 millimeters, we find the B. H. P. of the engine to be $\frac{10^2 \times 4}{5} = 80$. A very simple mental calculation which is just about correct, being based, of course, on assumed con-

THE *NAPIER MINOR.*

Most successful British motor boat.—This type of vessel affords the only means yet devised for attacking an enemy's submarines.

stant piston speed and volumetric efficiency. As a matter of fact, within limits, as the piston speed increases, the volumetric efficiency drops, so that an engine will give practically the same horse-power over a considerable range of speed, although the fuel economy will vary considerably. A glance at the accompanying curve diagram, which refers to an engine of the size mentioned, will show these points clearly. *A* shows the total B. H. P. developed at the various speeds; *B* is the horse-power at unit speed, or, in other words, the B. H. P. per revolution, multiplied by the normal revolutions (in this case 850), and shows the fall in volumetric efficiency; C shows the gasoline consumption in terms of gallons per brake horse-power per hour.

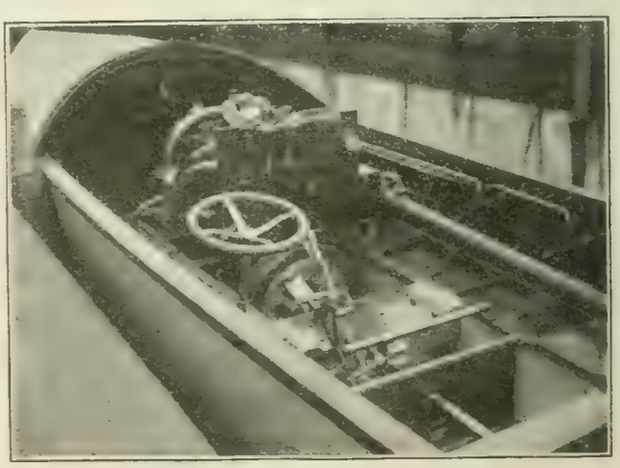
It will be noticed that, within 5 per cent the horse-power developed is constant from 740 to 1,130 revolutions per minute; but that, in this range, the consumption increases from 0.09 to 0.13 gallon per horse-power hour, owing mostly to loss of volumetric efficiency and carburetter error.

When the diameter of the cylinder is found in inches, it can be reduced to centimeters by multiplying by 2.54, one inch being approximately equal to 2.54 centimeters.

Motor Boats for Use in War

A TYPE of motor boat for which the claim is made that it affords the only effective means thus far devised for attacking an enemy's submarines, has recently been adopted by the British Navy. One of the new craft, illustrated herewith, is called the *Napier Minor.* In tests before representatives of the British Admiralty, this vessel has demonstrated its ability to travel 1,000 miles at a sustained speed of 25 miles an hour, without taking on a fresh supply of liquid fuel.

When in motion the boat is almost in-



MACHINERY OF THE "NAPIER MINOR."

Showing instrument board, clutch, steering wheel, and controlling levers.

visible in the trough of the wash which it makes as it progresses. Herein lies one of its advantages for scouting purposes. The exhaust gases, also, are made to leave the boat silently, and are rendered practically invisible, being discharged from the receiver into a water-jacketed pipe which permits them to pass into a silencer and then overboard.

Two boats of the same type have thus far been built, being the first of a series of high-speed cruising launches which it is proposed to construct. In unofficial speed tests, these boats have vanquished racing steam yachts of much greater length and double the horse-power. It is believed that a mosquito fleet of similar craft could be utilized with great advantage to protect seacoast towns against attack, and at a very small cost.

The value of the *Napier Minor* class of boat in harbor defense has been proved, experimentally at least, in the various tests to which it has been subjected. For one thing, a motor boat of this type would present a very difficult target to the big guns of a warship, not only because of its small size, but also because of the fact that, in the interval after the smoke from the enemy's gun was seen, and before the projectile could reach its mark, the boat might be stopped or its course altered. The extreme lightness of the boat and its consequent lack of momentum allow it to stop practically as soon as the engine is stopped. Lying low in the trough of its own headway, the *Napier Minor* while affording a means for watching an enemy, would itself be scarcely visible. Behind it a torpedo could be trailed; and after being launched at a submarine while the latter was on the surface, a return could be made without having given the enemy an opportunity to retaliate.

The hull of the *Napier Minor* consists of three slices of mahogany sewed together with copper wire. Though extremely light, it is much stronger than that of the ordinary type of motor boat. The hull is painted gray outside, and the decks white. The interior fittings are of

BRITISH MOTOR BOAT *Napier Minor*

polished mahogany. The craft is divided into two parts, the forward section containing the machinery, and the after section being reserved for a crew of from two to twelve men and an officer.

A turtle-back deck covers nearly the whole of the forward part, and underneath this are located the motor and other machinery. Further protection is assured against the spray by means of canvas hoods similar to a buggy top. So cast for the accessories formed of thin slices of mahogany sewed together, and is so placed that the steering wheel, which is exactly like that of an automo-

bile, and also the reversing and controlling levers, are all at hand.

The after part of the boat may be fitted with cushions and a hood so that the boat can be converted into a pleasure cruiser, or it may contain provisions, munitions, or anything that may be required. The one idea the builders have kept in mind, however, is that of a boat capable of maintaining a high rate of speed when required, and yet having a shipshape look for ordinary use. Owing to the special design of both the boat and her machinery, it has been possible to fulfill these somewhat severe requirements.

The machinery of one of the *Napier Minor* boats consists of an 80-horse-power petrol (gasoline) engine. The engine is suspended on horn plates held to fore-and-aft bearers, which in turn are stayed to the boat by gussets. The reversing gear, entirely enclosed, is carried on the same bearers, and is positive whether ahead or astern; it is purely a locked shaft without running gears of any kind, the spindle only of which is in motion. This gear-box is filled with oil for lubricating the bearings when the boat is in motion.

The boat may be controlled to a nicety by means of a clutch running in oil, which is actuated with very little effort; in fact the clutch may be forced out by merely pressing one finger on the lever. The shaft is carried through a bronze stern bearing, where it is again supported by bronze propeller brackets. The propeller is of phosphor bronze, and is designed to absorb the whole of the power of the engine when running at a speed of 1,100 revolutions per minute. The cylinder of the engine is cooled by the circulation of water, which is forced around it by a slow-speed centrifugal pump having a large capacity and driven directly by a chain from the crank shaft. The exhaust consists of a water-jacketed receiver into which the exhaust pipes lead. The gasoline is carried in a tank stowed away in the hold, and is pumped up as required to feed the tank above the engine under the forward part of the turtle-back. The boat can be controlled easily by one man, and a crew of two is ample to do everything that is required.

The motor lifeboat is another development of the application of the gas engine to water craft which is just now interesting English marine engineers. In March of the present year, successful experimental trials of lifeboats equipped with motors took place at Newhaven, where the National Lifeboat Association placed a two-cylinder 10-horse-power motor in one of their boats. The problem of the successful use of the motor in a lifeboat, however, presents difficulties not met with in other kinds of boats, as the motor must be so boxed up inside a perfectly water-tight case that its working will be unaffected by the waves that break on board. Moreover, the motor must be as completely automatic as possible, as the attention which the engineer would be able to give it on a cold, dark night would not be very great.

The Modern Ram

THE ram depicted in our illustrations is being fitted to the British battleship *Britannia* soon to be launched at the Portsmouth Navy Yard.

A modern ram is nothing more than a huge steel beak, or spur, which is fitted to the prow of a battleship for the purpose of destroying an enemy's ship in

PLACING 40-TON RAM OF BRITISH BATTLESHIP "BRITANNIA" IN POSITION.

The bottom end of the ram is attached to the vessel's keel, and the space between the ram and the ship is walled up with steel.

war time by the force of collision. Indeed, should a vessel succeed in driving her ram against another warship, the blow, if delivered at full speed, would be sufficient to crush in the ship's side and sink her immediately. A battleship's ram, such as the one shown in our illustrations, weighs about forty tons, and is cast in one piece. It is of solid steel, and capable of striking a tremendous blow. Shell-proof a man-o'-war may be made, but the skill of the naval architect is unequal to the task of designing a ship that can resist the ram.

Great care has to be exercised in fixing such a heavy piece of steel. The method generally adopted is as follows: The ram is suspended from a strong derrick, its bottom being attached to the extreme end of the vessel's keel-plates. The gap between the ram and the uncompleted part, or hull, is walled up with steel divided into many water-tight compartments. The weapon is so fixed that it strikes just beneath the armored belt, where resistance is weakest, while it is so shaped that the ramming vessel can, by reversing her engines, easily disentangle herself from the ship she has struck.

As a weapon of naval warfare, the ram is one of the most ancient of which we have any recorded history. It was used with deadly effect in the naval fights of Greece and Rome; and, in later times —as at Lissa, where the Austrians defeated the Italians in 1866, and during our own Civil War—it proved a terrible engine of destruction.

The value of the ram as attached to the huge and swiftly moving warships of modern navies has yet to be determined; and many authorities claim that the ship using it is liable to be only less badly strained and shaken up by the shock than her opponent.

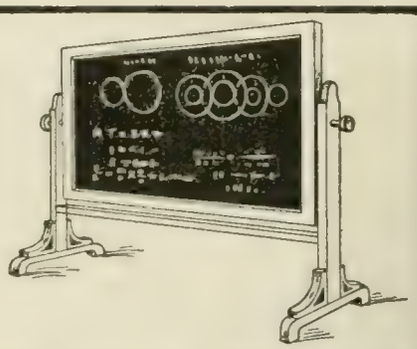
In some respects the most unique ship in the American Navy is the armored ram *Katahdin*, which was designed for the express purpose of ramming. Her hull was constructed with a view to enabling her to withstand the terrible wrench that a ship running its nose at full speed into a moving vessel is certain to suffer. The *Katahdin* is so built that the vessel may be submerged to her fighting trim by means of [illegible] Kingston outboard valves, one in each transverse water-tight compartment of the double bottom. When not submerged, the vessel is designed to have sufficient freeboard for coasting service.

To gauge something of the terrible damage a ram is capable of inflicting, one has only to recall the case of the *Victoria*, flagship of the Mediterranean Squadron, which was rammed by the *Camperdown* and sunk with Vice-Admiral Tryon and about 400 men in 1893. Accidents with rams have also happened nearer home. In 1895, while the Channel fleet was off the Irish coast, the *Vanguard* was accidentally rammed by the *Iron Duke*, and sank in an hour. During the German naval manœuvres of 1895 the *Grosser Kurfürst* was rammed by the *König Wilhelm*, and sank immediately, 269 of the crew being drowned.

It is interesting to note that during the American Civil War the ram was first employed in warfare between the Federal fleet and the Confederate armor-clad ram *Virginia* at Norfolk Navy Yard in 1862, when the Federal frigate *Cumberland* was rammed and sunk by the *Virginia*.

CHALK TALKS

by CARL S. DOW.



Number Fifteen—Horse-Power of Steam Engine

IN Chalk Talk Number VI (August, 1904), we learned that the indicator is an instrument used in steam-engine testing for determining the steam *distribution,* that is, the points of admission, cut-off, release, and compression. Still further we found that the indicator diagram is proportional to the work done by the steam.

The average net pressure (called the *M. E. P.,* or "mean effective pressure") is found by dividing the area of the diagram by its length, and multiplying by the scale of spring. The reason for this is very simple; the area of any plane figure is equivalent to that of a rectangle having the same length, and a height equal to the mean width of the figure. Therefore,

$$\text{Area} = \text{Length} \times \text{Height};$$

or,

$$\text{Area} \div \text{Length} = \text{Height}.$$

Now, this height, multiplied by the strength of the spring used when making the indicator diagram, equals the *M. E. P.* This is the average net pressure acting on the piston throughout the stroke. It is measured in pounds per square inch. This pressure is very important, as it is used in calculating the power of the engine, usually called "indicated horse-power" *(I. H. P.).*

Horse-Power

The term horse-power is a unit or measure of power; it is found by multiplying the acting force or pressure by the distance through which it acts in one minute. More accurately:

To find the indicated horse-power of a steam engine, multiply the net pressure (in pounds) acting on the piston, by the distance the piston moves in one minute, and divide the product by 33,000.

The above is the general rule and principle, but has been simplified as follows:

Multiply the M. E. P. (in pounds per square inch) by the area of the piston (in square inches); then by the length of stroke (in feet); and then by the number of strokes per minute. Divide the product by 33,000.

In order to put this rule in a form easily remembered, the items are abbreviated by using the initials, as follows:

P = Mean Effective Pressure (in pounds per square inch).
L = Length of Stroke (in feet).
A = Area of Piston (in square inches).
N = Number of Strokes per minute.

$$\text{Therefore Horse-power} = \frac{P\,L\,A\,N}{33{,}000}.$$

Of the above-listed quantities, P is found from the indicator card as already explained. L is known from the dimensions of the engine; it is equal to twice the length of the crank. A is found in the same way as the area of any circle, that is, by multiplying the square of the diameter by .7854. N may be determined by multiplying the number of revolutions by 2, if the engine is double-acting, as is usual.

The illustration on the blackboard is an attempt to show how these items are obtained. The numerous arrows on the left-hand side of the piston indicate high-pressure steam; those on the right-hand side indicate low-pressure steam. The difference between these pressures is the effective pressure. The length of stroke is the distance the piston moves; this is not equal to length of cylinder, because of thickness of piston, and slight clearance at each end. The area of the piston is a circle, as shown.

It might be well to state here that if the horse-power is to be found accurately, the area of the piston-rod is subtracted from the area of the piston, and this difference is used as the value of A for the *crank end.* If no allowance is made for the piston-rod, the calculation is much easier, and the error is only about 2 or 3 per cent.

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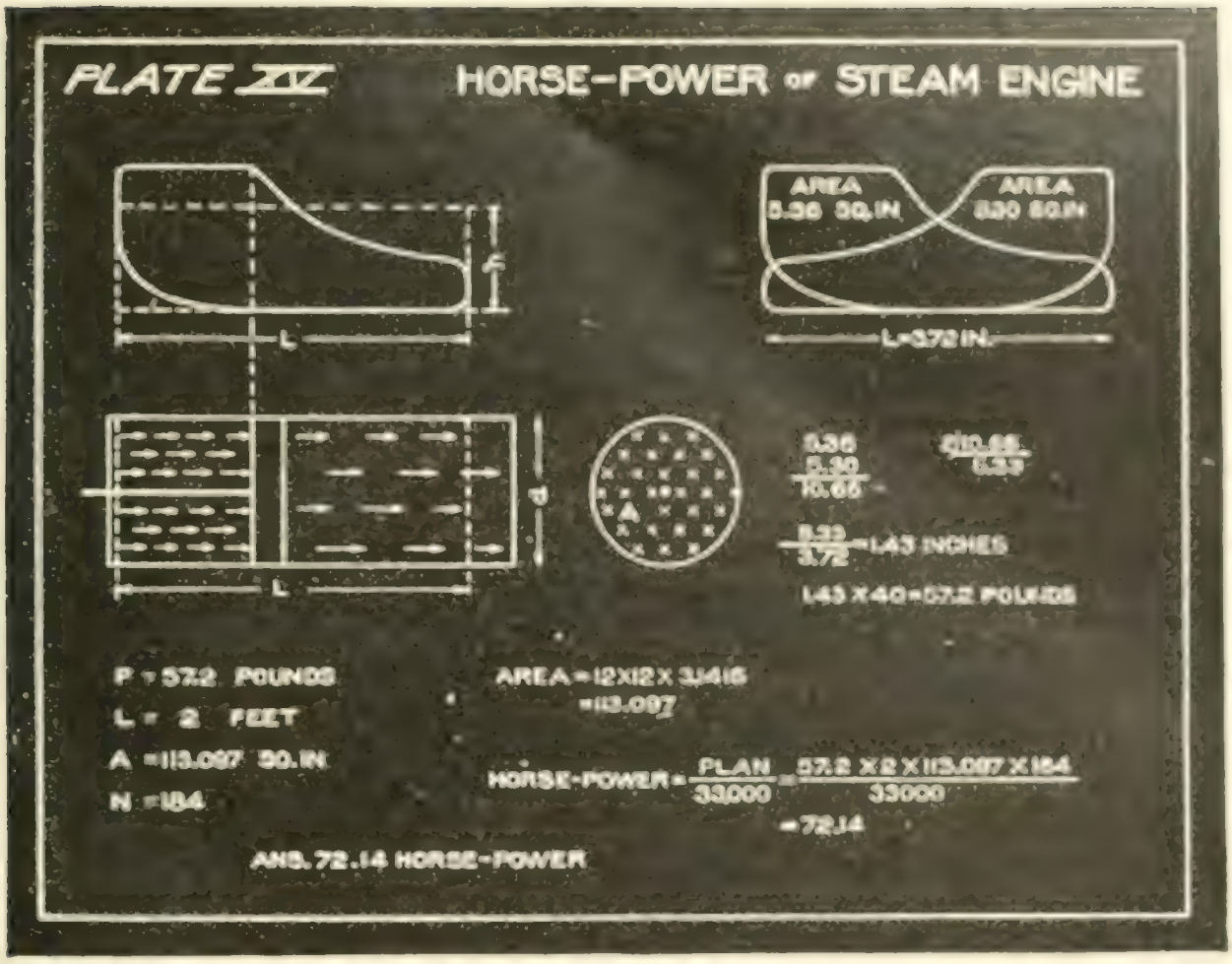


In case the cards from the two ends of the cylinder are not of the same area (and they are seldom alike), the two areas may be averaged.

An Example

Suppose we have an engine of the following dimensions:

Piston 12 inches in diameter;
Stroke 24 inches, or 2 feet;
Revolutions 92 per minute; or,
Strokes 184 per minute.

While running at this speed, cards were taken; these cards measured 5.36 and 5.30 square inches, and were 3.72 inches long. A 40-pound spring was used. Let us find the horse-power.

The average area of the cards is found by adding the two areas and dividing by 2. Thus,

$$\frac{5.36 + 5.30}{2} = \frac{10.66}{2} = 5.33 \text{ sq. in.}$$

We know that the mean ordinate is equal to area divided by length; or,

$$\frac{5.33}{3.72} = 1.43 \text{ inches.}$$

Now, if one inch=40 pounds (scale of spring), then

$$1.43 \times 40 = 57.2 \text{ pounds} = P.$$

The length of the stroke = 2 feet = L.

The area of the piston is equal to the area of a circle 12 inches in diameter:

$$12 \times 12 \times .7854 = 113.097 \text{ sq. in.} = A.$$

Since the engine is double-acting, the number of strokes per minute equals the number of revolutions multiplied by 2:

$$92 \times 2 = 184 \text{ strokes} = N.$$

We now multiply these four quantities together and divide by 33,000:

$$\frac{57.2 \times 2 \times 113.097 \times 184}{33{,}000} = 72.14 \text{ H. P.}$$

Let us see what the difference would be if we considered the piston-rod.

Assume the rod to be 2 inches in diameter. The area of a circle 2 inches in diameter = $2 \times 2 \times .7854 = 3.1416$ square inches. Then the area of the piston for the crank end would be $113.097 - 3.1416 = 109.9554$, or in round this value, we get as the horse-power for the crank end:

$$\frac{57.2 \times 2 \times 109.9554 \times 92}{33{,}000} = 35.07$$

In the preceding calculation we averaged the areas of the diagrams, and, according to our results, we considered each end to develop $\frac{72.14}{2} = 36.07$ horse-power. Now that we deduct the piston-rod, we get $36.07 - 35.07 = 1.01$ H. P. for the engine, or, our previous calculation was in error 1.01 horse-power, which is approximately 1.5 per cent.

Blowing Off Steam

What is It?

A BUZZ—a whirr—
A cloud of dust
A wild, blood-curdling yell—
A ghastly object flashing by—
Then silence—and a smell!

She "Raised" Him

A YOUNG man who has not been married long, remarked at the dinner table the other day: "My dear, I wish you could make bread such as Mother used to make." The bride smiled, and answered in a voice that did not tremble: "Well, dear, I wish you could make the dough that Father used to make."

The Defendant

A LAWYER had as client a negro who was accused of stealing chickens. Things were going in the darkey's favor, until he was placed on the stand.

"Are you the defendant in this case?" asked the judge.

"No, sah," he replied, with an amazed look on his face and pointing to his counsel, "dat man over dar, he's de defendant; I'se de gem'an what stole de chickens."

The Modern Warrior

THE following is from an essay on the Japanese, written in the recent grammar-school examinations by a lower-school boy: "Until recently the Japanese used to fight with bows and arrows, but now they are equipped with the complete arms of a Christian."

Absolved

IT is told of the witty old French abbé, Père Monsabre, that on one occasion a lady sent a message to him just as he was entering the pulpit, that she must see him. After much beating about the bush, she came to the point. Vanity was her besetting sin, and only that morning she had yielded to the temptation to gaze at herself in the mirror, and indulge in the thought that she was very pretty. Père Monsabre looked at her steadily for a minute; and then, in his soft, musical voice, he inquired kindly: "Is that all, my daughter? Go in peace. For to make a mistake is no sin."

Shop Talk

"MY DARLING," he exclaimed, rapturously. "How brilliant you are! You fairly—er—bristle with ideas." The Chicago girl drew herself up to her full height, and brushed him haughtily aside as she swept out of the room. "You seem to forget"—she turned on her heel at the door and faced him—"that I cannot brook any reference to my father's business."

Her Easter

THE maid servant rushed suddenly into the boudoir with a seriously-sad expression.

"The master is lying unconscious in the hall, ma'am, with a large box beside him and a paper like a bill crushed in his hand."

MISTRESS: "Ah! my fifty-dollar new hat has come. Do bring it up, Mary!"

No Wonder it Bored Bill

BILL had a billboard. Bill also had a board bill. The board bill bored Bill so that Bill sold the billboard to pay his board bill. So, after Bill sold his billboard to pay his board bill, the board bill no longer bored Bill.—*Yale Expositor.*

Diagnosis

DR. OSLER, of Baltimore, was once called to attend a woman of seventy who had tried many physicians without relief to her aches. Her husband offered Dr. Osler $100 to tell him what ailed his wife.

After listening to a few details of his patient's illness from the trained nurse, Dr. Osler was ushered into the sick room. He felt the woman's pulse, listened to the heart, and took the respiration after the approved method. Then he went downstairs, where the husband was anxiously waiting for him.

"The trouble with your wife," he said, as he carefully adjusted his gloves, "is that she is seventy years old. That is all."

Go Ahead

'TIS well to look before you leap,
Lest leaping you should fall;
But oftentimes it doesn't pay
To carefully the chance to weigh,
Or you may look and look always
And never leap at all.
—*Chic*

Characteristic

AN absent-minded professor was one day observed walking down the street with one foot continually in the gutter, the other on the pavement. A pupil, meeting him, saluted him with: "Good evening, Professor. How are you?" "I was very well, I thought," answered the professor; "but now I don't know what's the matter. For the last ten minutes I've been limping."

Forethought

"SOMETIMES I wish," said the very lazy man, "that I liked to work, so it wouldn't be so disagreeable to me when I am compelled to do so. And then I get to thinking that maybe if I liked it I would be at it all the time, and I can't bear the thought."

Force of Habit

SMITH.—"Why is Brown carrying his arm in a sling?"

JONES.—"Oh, his horse kicked him and broke it. He went out horseback riding the other day instead of taking his automobile; and when the horse balked, he got off and twisted its tail—from force of habit, you know."—*The Automobile*

Equal to the Occasion

EMPLOYER.—Well, look here, Jimmie, this is the third time you have asked to go to your grandmother's funeral. How does it happen that you have three grandmothers?

OFFICE BOY.—Well, yer see, one uv me grandmudders wuz twins.—*Judge*.

Success

"WHAT is the secret of success?" asked the Sphinx.

"Push," said the Button.

"Never be led," said the Pencil.

"Take pains," said the Window.

"Always keep cool," said the Ice.

"Be up to date," said the Calendar.

"Never lose your head," said the Beer.

"Make light of everything," said the Fire.

"Do a driving business," said the Hammer.

"Aspire to greater things," said the Natmeg.

"Be sharp in all your dealings," said the Knife.

"Find a good thing and stick to it," said the Glue.

"Do the work you are sooted for," said the Chimney.

Worm Turns

"FIVE years ago to-night, Henry," remarked Mrs. Peck, who happened to be in a reminiscent mood, "you asked me to say the one little word that would make you happy for life."

"Yes," rejoined Henry, with a sigh long drawn out, "and, womanlike, you had to go and say the wrong word."

Heard Along the Santa Fé

"MIKE," said Dealing Pete, "we're gittin' left again." "What's the matter?" asked Meandering Mike. "Well, if dese railroads gives rebates to de people dat pays de fellers dat rides free ought to have a bonus."

A Song of Work

SPLIT up de kindlin',
Plow up de groun';
No use ter wait 'twel de
Worl' turns roun'.
Soon—too soon will de
Trumpet soun';
Go ter work, believers!

Take in de joy er de mawnin' light;
Foller de flag in de stormy fight;
Soun'—fer soon come de long night;—
Go ter work, believers!
—Frank L. Stanton in *Atlanta Constitution*

Darkey Wit and Wisdom

WHEN a man does his work in a hurry, en makin' de other feller saw de wood.

WHEN you meet trouble in de big road, roll up yo' sleves en shake Joy down out de tree-tops.

SATAN don't go roun' in sheep's clothin' in dis day en time. He des follers de fashion, like de rest of 'em.

HAIL an oldey settun' lookin' fer de ar' calamity happenin' fer 'em, dey ain't a one mo' quick ter take hit heaven in a automobile.

"DE worst trouble wid us darkies is we don't git along," said a noted philosopher, "we don't settle down diligent an' industrious when we gits ter pushin' a wheel-barrer."

Life of a Splash

A COMPLETE record of a single splash resulting from the fall of a rough steel ball into water, is illustrated by a series of remarkable photographs taken by Arthur C. Banfield, and recently exhibited by him at the Royal Photographic Society's display in London. For each picture, the ball was allowed to fall into the fluid, but the exposure was delayed each successive time by an increasing fraction of a second. The exposures were made by the light of an electric spark lasting between ten and seventeen ten-millionths of a second. The timing was under perfect control. By the use of a specially designed chronograph, the ball may be photographed at any period after its release, from a thousandth of a second up to three seconds.

Thus the pictures were not obtained by the ordinary cinematograph process, which would have been entirely too slow, but by a refinement of the process.

In the second photograph, we see the steel ball half embedded in the fluid (in this case, water), to which, for photographic reasons, a little milk has been added. We notice that it is surrounded by an exceedingly beautiful ring or sheath of fluid, which bears on its outside edge some fine fronds. The liquid seems to be repelled in some mysterious way from the ball, giving the surrounding ring a curl outward. No. 3, photographed one two-hundredth of a second later, shows the coronet at its best; the fronds, or spikes, are now plainly discernible. Their life is a very short one, owing to the action of surface tension, which may be described as the steady pressure of the elastic skin which science assumes all fluids to possess.

It will be noticed that under this influence our fairy coronet quickly loses its

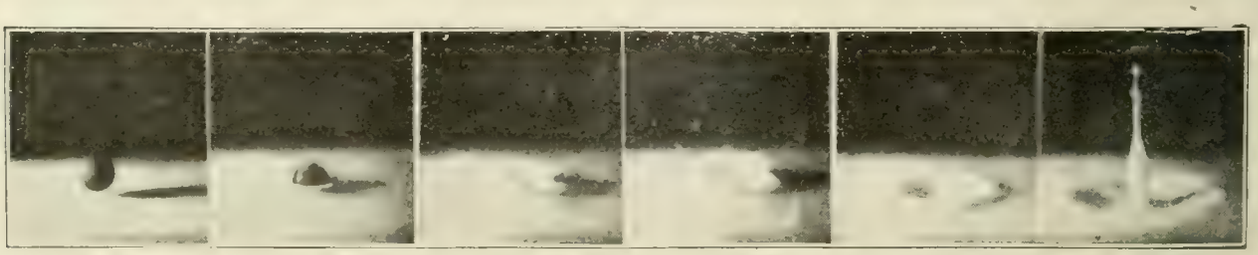


Fig. 1.—0s. Fig. 2.—.005s. Fig. 3.—.010s. Fig. 4.—.015s. Fig. 5.—.06s. Fig. 6.—.065s.

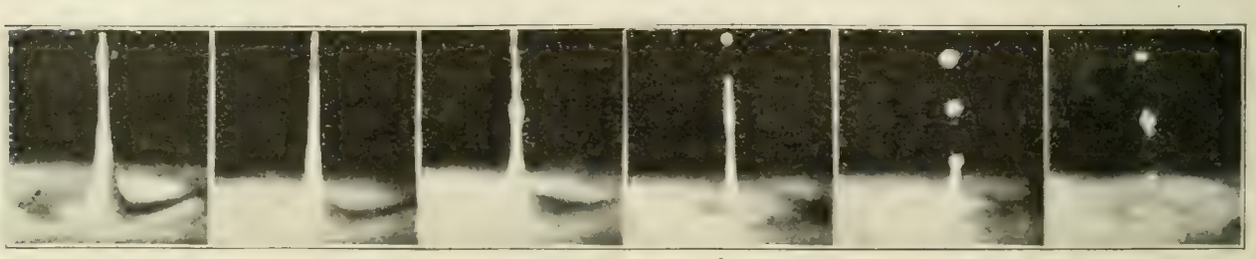


Fig. 7.—09s. Fig. 8.—.095s. Fig. 9.—.13s. Fig. 10.—.18s. Fig. 11.—.185s. Fig. 12.—.23s.

STAGES IN THE LIFE OF A SPLASH OF WATER.

Figs. 1 to 5 trace the fall of the ball into the fluid; Figs. 6 to 12, the rise of the column of fluid and the beginning of the first concentric ripple.—The numerals following the figure numbers indicate the fraction of a second expired between release of ball and taking of picture.

fronds. In the fourth photograph, they have nearly disappeared, being discernible only in the form of tiny spots all but invisible in the reproduction. The base of the frond has thickened into the form of a "lobe" projecting from a rim of fluid which now bears the appearance of a "crater" rather than of a coronet. In the fifth photograph shown, our beautiful fairy coronet finally becomes a mere ring surrounding a hole in the water, of the depth of which the picture gives but little idea. As water is not compressible, it follows that the level of the water in the vessel must have risen according to the size of the hole.

Mr. Banfield's pictures were exhibited in a series, every one numbered, and reaching from No. 1 to No. 32; but as there is very little difference in the appearance of many of them, we have decided to omit all except those necessary to demonstrate the most important stages in the record of the splash.

Although there is very little alteration in the surface appearance between Nos. 10 and 12, great things are happening down below, the result of which is the emergence of the jet in No. 14 (Fig. 6). It shoots out of the crater with great velocity, and although the extreme tip can just be seen emerging in the center of No. 13 (Fig. 5), the jet attains the dimensions shown in the next photograph in one two-hundredth of a second.

At a depth equaling three and one-seventh times the diameter of the ball, the hole divides, and, owing to the displaced fluid flowing to regain its original level and to the pull of the elastic lining of the hole, a pillar shoots up. The crater gradually disappears and develops into the first concentric ripple, the familiar phenomenon observed when a stone is thrown into a pond. As support wanes, gravitation reasserts itself, and the curve of the base changes from concave to convex. Finally the column collapses, and falls in large drops.

CATTLE KILLED BY LIGHTNING STROKE

Strange Effect of Lightning

LIGHTNING in Illinois has often performed most remarkable feats during the autumn months when the air is generally overcharged with electricity; but no phenomenon on record is so strange as the one that recently occurred near Plainfield, Ill., when an entire herd of twenty-eight cows was struck down in an instant by a flash during a thunderstorm. The cows had become frightened during the storm, and had run to the wire fence in their efforts to escape. All were standing against the fence when the lightning struck a tree to which the wires of the fence were attached, about forty feet distant. All the cattle dropped simultaneously, stone dead, without quivering a muscle after their fall. The phenomenon was witnessed by farm hands returning from their work

and caused great excitement throughout the district. There were no signs of the effects of the lightning on the fence, and hence it is believed that the cattle were killed by what is known as the "return stroke." Persons standing near a conductor have often received slight shocks when the lightning has struck some near-by object. The conductor, of course, must have had a high electrical potential just before the lightning occurred, which was suddenly reduced to an enormous extent by the discharge. Dark streaks were found under the skins of the cows when the hides were removed. The occurrence has created a prejudice against wire fences among the farmers of the district where the accident took place.

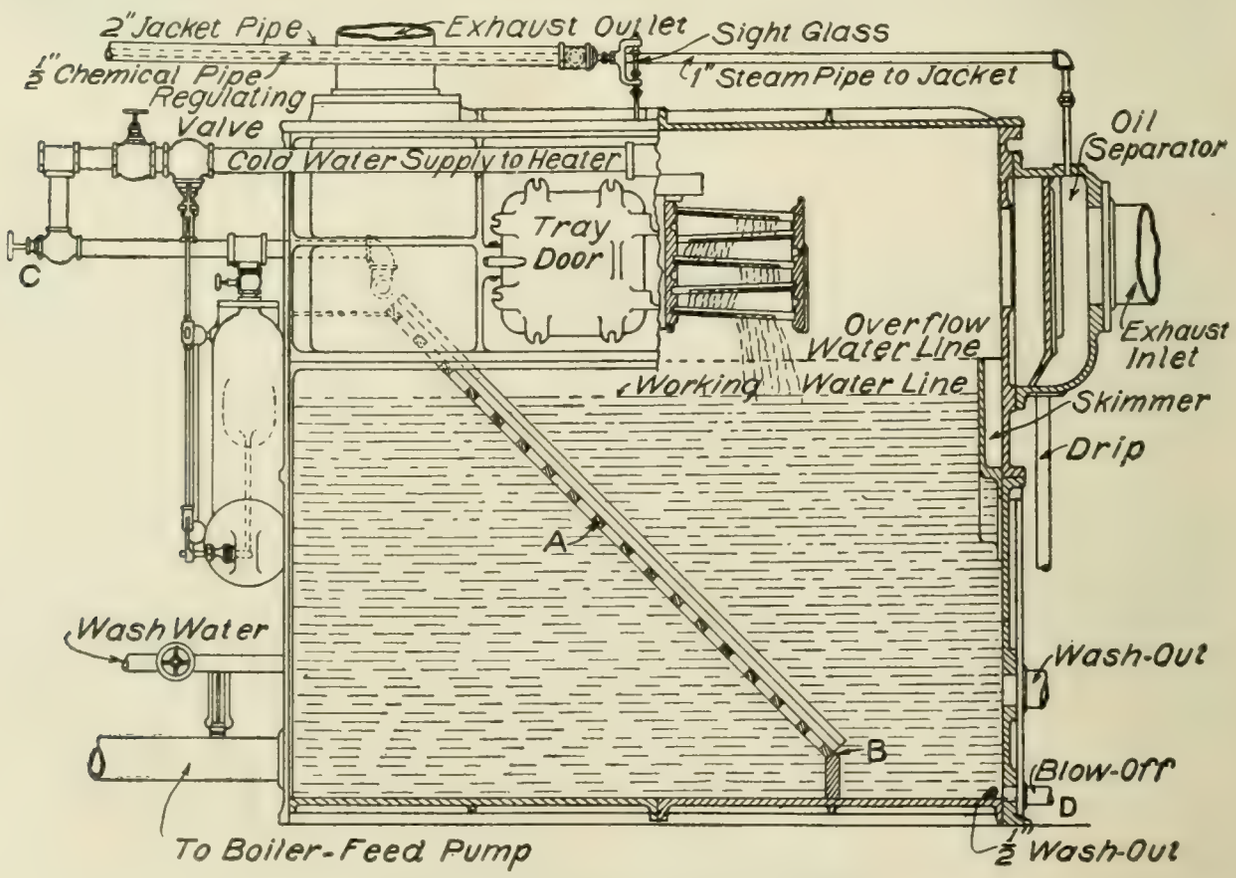
Every autumn brings about some strange lightning phenomenon in Illinois, which State seems to be a kind of radiating point for the tail ends of all storms that occur in America—north, south, east, and west.

In the autumn previous to this accident at Plainfield, thirteen persons were killed by a stroke of lightning while standing on a pier fishing in the lake at Chicago.

A New Feed-Water Filter

THE advantage of feeding only pure water to boilers was never more realized than at the present time. With very impure water, it becomes absolutely necessary to provide some means for filtering the same, as well as to remove the scale-forming matter, since, if fed to the boiler, it will cause foaming and overheating of the plates, which is uneconomical as well as actually dangerous.

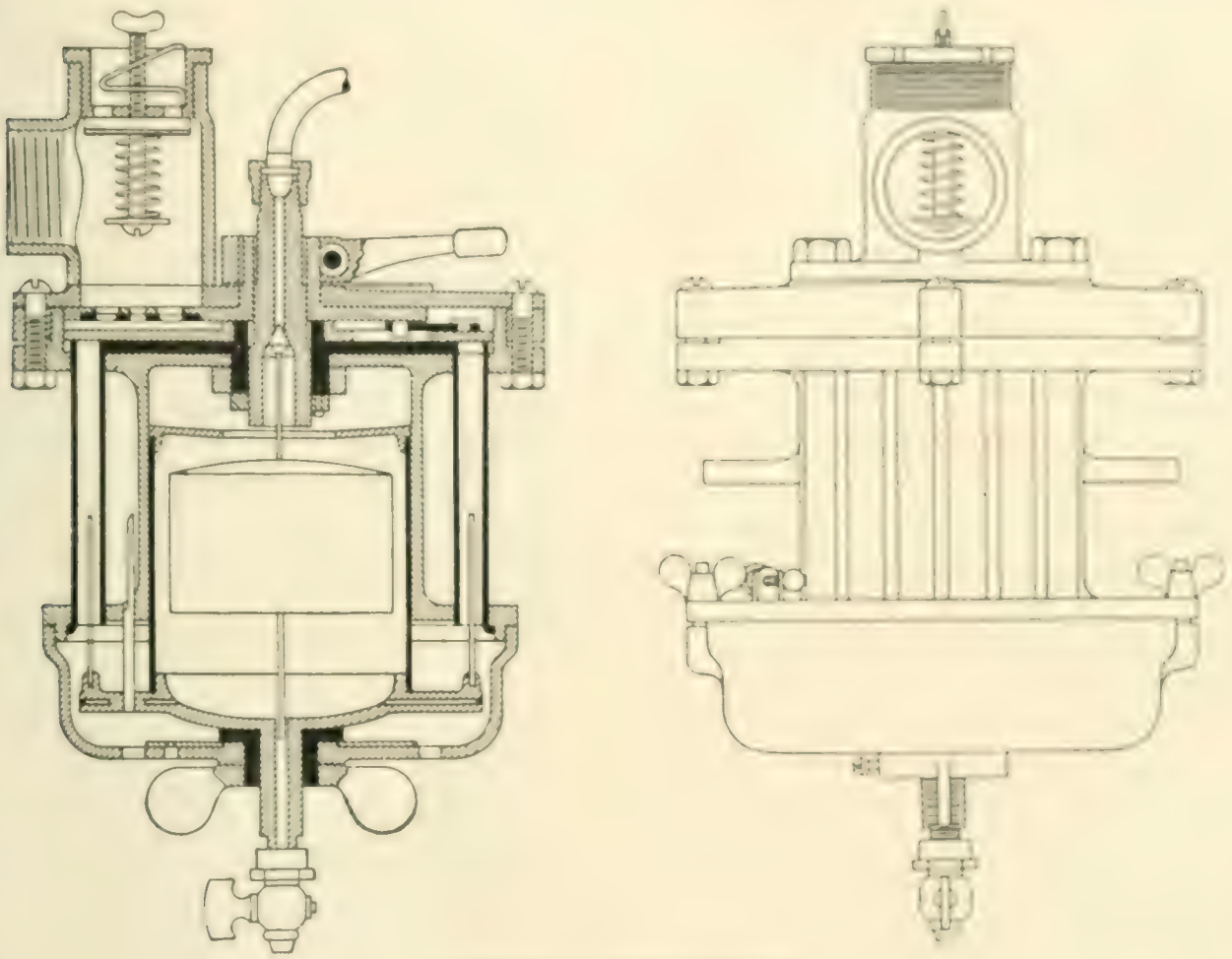
Mr. O. L. Stump, of Marion, Ohio, a student of the American School of Correspondence, has made some experiments with various filters, and has found that the one illustrated here, which is his own invention, is by far the most successful at his plant. The filter is installed in a Cochrane heater. From the figure it will be seen that it consists of a tight partition, placed across the bottom of the heater, which serves as a rest for the filter. Angle-irons are then securely fastened to the inner wall of the heater and in line with the top of the partition, extending a little above the water line.



NEW TYPE OF FEED-WATER FILTER.
Invented by a Student of the American School of Correspondence.

Across these angle irons, a supporting grate *A* is laid the full length of the bed. The muslin filter cloth is stretched on top of the grate. A channel grate is then fastened on top so that it provides a place for the next cloth, and also leaves a number of open channels running from top of filter to bottom *B*. As many cloths and grates can be used as are necessary. The sediment, which is precipitated by coming in contact with the exhaust steam and by being treated with Sorge chemical, is stopped by the filter, and through natural causes will travel to the lowest place, at the blow-off, whence it can be removed at will. If any sediment should pass through the cloth, the second cloth arrests it, and the channel provides a ready means for it to pass to the blow-off. A perforated pipe is placed at the top of the filter, and connected to a fresh water supply, so that the filter can be flushed at any time if necessary. When the water has been pumped from the filter, flush valve *C* is opened, as is also blow-off valve *D*.

The inventor claims that he has not only increased the filtering area in a heater of given size by placing the filter on an incline, but has also increased the amount of filtered water to draw from, and has increased the head 4 feet. In actual practice, the original filter had to be removed and cleaned every 24 hours; but the improved one, it is claimed, has been in successful operation for six months, with cleanings only every two weeks.



COSTELLO CARBURETTER.

A New Carburetter

THE Costello carburetter, the invention of a Chicago man, is attracting considerable attention in the East. The device is unique in its construction and method of carburization. It possesses the usual float and needle valve to maintain a constant level of the gasoline; but in the making and regulation of the mixture, it departs from usual practice. Mechanically the device

is a series of movements designed not only to regulate the amount of carburetted air required at varying speeds of motors, but also to determine the amount of fluid contained in each foot of air carburetted. There are twelve mixing chambers in the carburetter, as shown in the illustration, but the plurality of chambers may vary in number according to the capacity in cubic feet required by the motor.

Air is taken in through the ports in the lower cover, the twelve tubes being simply mixing chambers, each having an individual gasoline nozzle which is threaded into a hollow stem leading from the float-feed chamber. A revolving disc located at the inlet chamber of the mixing chambers, and with holes of the same diameter as the mixing chambers, is actuated by a screw on the outside housing of the carburetter. Backing this screw up tends to close all chambers in equal degree. In this manner the air velocity is increased or decreased to suit atmospheric conditions. Spraying nozzles of various outlet capacities are needed for different motors. Nozzles from .01 to .02 inch in diameter have proved the sizes most generally required.

Owing to the arrangement of the float-feed chamber in a central position, going up or down hill does not starve or flood the fluid supply. It is possible to raise the fluid supply nozzle about one-half inch above the constant level of the fluid, by means of a threaded drip stem extending from the base of the fluid chamber. This adjustment allows for the satisfactory use of fluids of various specific gravities. By unfastening the two wing nuts at each side of the lower cover, the float-feed chamber, spray nozzle, and needle valve may be removed and inspected. There are no delicate parts to loosen in removing the base.

The upper housing contains a rotating valve which cuts off or throws into the suction of the piston of the motor one chamber at a time. This valve may be set to leave one, two, three, or four chambers open; and to throw itself out of commission, being then locked tight. With one, two, three, or four chambers open, as required—two being generally sufficient—and the multi-unit valve locked, a damper valve on the outside of the carburetter throttles for very low speeds, the damper being left open just enough to keep the motor running. It is thus obvious that the carburetter is economical in allowing any desired number of chambers to be closed, so that the extent of operation of the carburetter is gauged by the needs, and the gasoline and air cut off accordingly.

A "pickler" on the float is said to be unnecessary; and, by closing the multi-unit valve so that three or four chambers are open, the velocity of intake is strong enough to make the device self-priming.

Doctoring a Rattlesnake.

Doctoring a Snake

A DISEASE which frequently afflicts poisonous snakes is cancer in the mouth. It can be cured by applying a salve to the diseased portion, but one

must run the risk of being bitten. An expert snake-handler, however, can grasp the reptile in such a way that it cannot strike with its fangs. The accompanying photograph is of a large rattlesnake in captivity, being held so that it is harmless while the attendant waits for the snake doctor to apply the salve to the cancer. As the photograph shows, the animal is grasped just behind the head, and the thumb and fingers are pressed upon the muscles controlling the fangs, so that they cannot be moved.

New Trolley-Guard

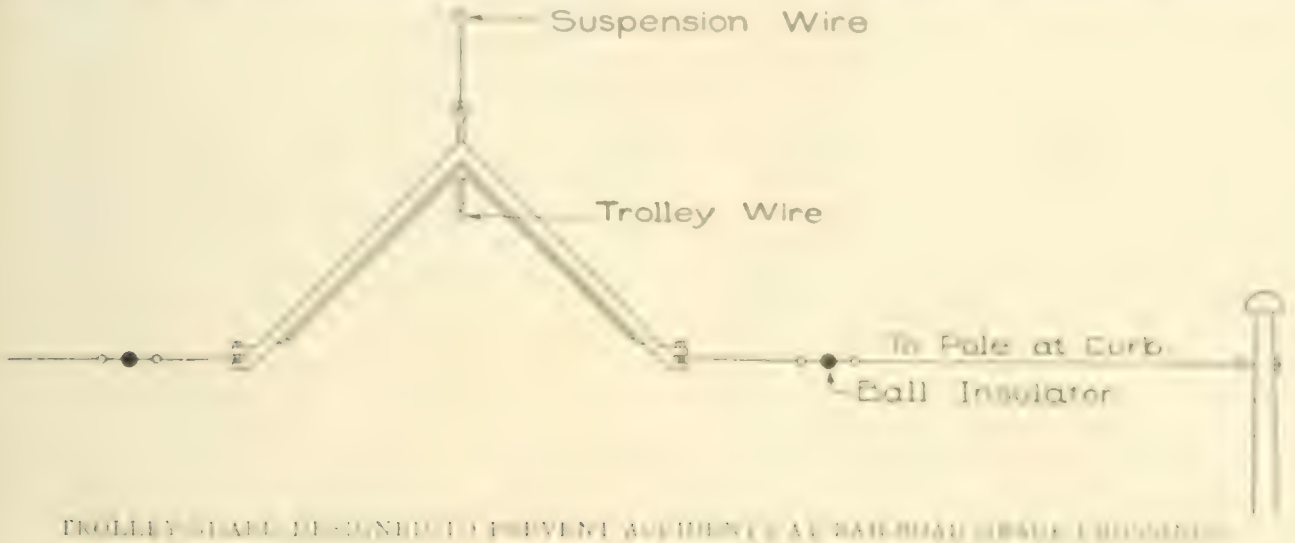
VARIOUS methods are followed in different locations, for the prevention of accidents at grade crossings where electric cars cross railroad tracks, the most common being the stopping of the trolley car at a short distance from the track, while the conductor runs ahead and signals if all is clear. The derailing system has many followers, and has been in use for several years. With this system, a switch with a short curve turning toward the curb is located several yards from the railroad on the main track of the electric line; unless this switch is thrown by conductor or other attendant, the derailing of the car follows. The switch is so placed that a good view of the railroad is procurable in either direction, and while not infallible has greatly reduced the percentage of crossing accidents. This system is also frequently used at the approaches to bridge draws.

The safest plan, of course, is the entire elimination of the grade crossing; and in many cities this has been successfully carried out. Not only is safety thus assured, but the delay to car service caused by the switching and slow moving of long freight trains is done away with. Damage suits, too, become a thing of the past.

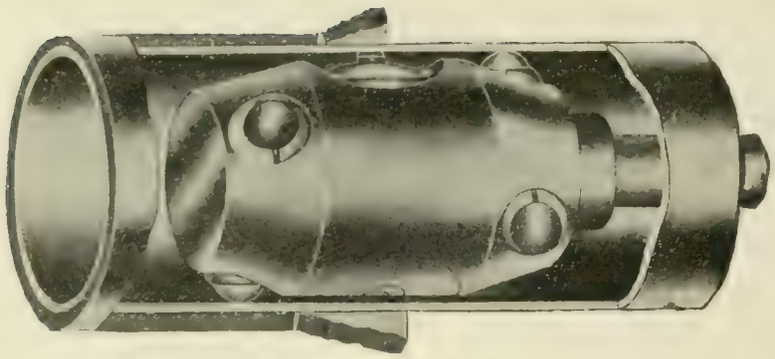
Steam railway companies are sometimes made responsible for the crossings operating safety gates by air from a tower beside the tracks. The tower is so located and is built with such an elevation as to give the operator in charge of the gates an unobstructed view up and down the tracks.

In spite, however, of these various precautions, many accidents still occur at grade crossings. They are in many cases due to the poor condition of the street railway tracks, resulting in the throwing of the trolley from the wire. This condition becomes doubly dangerous at night, when the car is plunged into darkness. It is to overcome the liability to occurrences of this kind that the device shown in the accompanying illustration has been designed. This consists of an inverted V-shaped trough of metal covering the trolley wire where it crosses the railway tracks.

The sketch illustrates very clearly this valuable device, which can be constructed easily and at a moderate expense by any street-railway system. The device is used with entire success in many of our larger cities.—ARTHUR B. WEBB.



TROLLEY GUARD DESIGNED TO PREVENT ACCIDENTS AT RAILROAD GRADE CROSSINGS



Section of Boiler Tube with Cleaner.

An Improved Boiler Cleaner

ONE of the principal difficulties operating against high economy of steam boiler operation is incrustation. Even the best-informed steam users scarcely appreciate the extent of the waste due to this source. From experiments it has been learned that a scale 1-16 inch thick will interpose so much heat insulation between the iron and water as to require 12 per cent more fuel than when the boiler is clean; while scale ¼ inch thick will practically double the quantity of fuel required to perform the same duty. The market is flooded with remedies good, bad, and indifferent, by which to combat and prevent this incrustation. A very excellent way to remove the hard scale when it has once formed on the tubes is by means of hammer cleaners.

The accompanying views illustrate a machine of this class, devised by a manufacturing company of Buffalo, N. Y. In this cleaner the motive fluid is applied in the most direct manner, thus insuring the greatest speed of piston. The double-acting knocker-rod is firmly secured to the piston; but it is claimed that the travel of the knocker-rod is so limited, that, although it is capable of exerting a sufficiently hard blow on the tube, there is practically no danger of puncture or other injury from its use. The construction of this apparatus makes it possible to operate the machine safely at boiler pressure, thus obviating the necessity of using a separate steam gauge or reducing valve to lower the pressure.

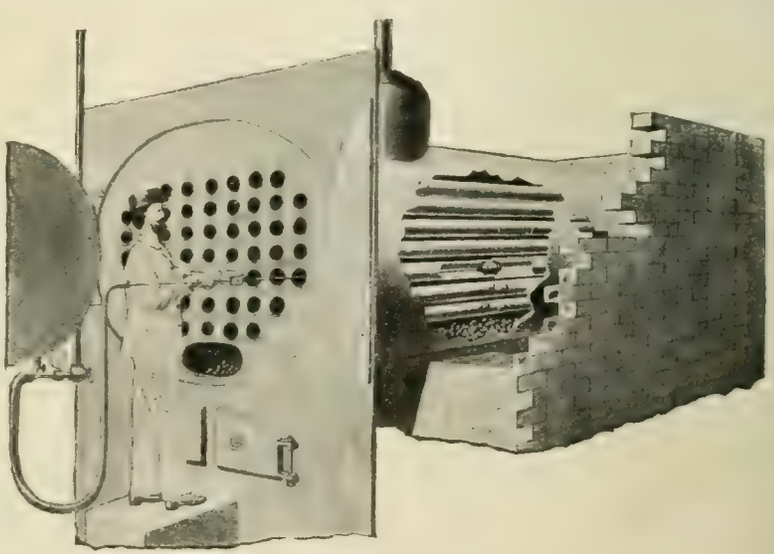
For obvious reasons, the body of the machine must be made considerably smaller than the inside diameter of the tubes; and this, in connection with the rest of the construction, necessitates some means of accurately maintaining the machine in the axis of the tube. This is accomplished by two sets of centering lugs—one ahead and one back of the piston—which are forced out against the inner surface of the tube by steam pressure.

Results of tests recently made, of these hammer cleaners, show that a light, rapid blow is more effective in removing scale than a slow, heavy one, and is also less likely to injure the metal of the tubes. An actual test of the machine illustrated shows a speed of 3,000 strokes and upwards per minute, according to the pressure used.

Undue heating of the tubes operated on—which would introduce a factor of considerable danger — is avoided by so using the steam that it is expanded to such a point that its temperature is only a little above that of the atmosphere.

A Natural Bridge

THE great Northwest abounds in natural wonders. One of the many interesting sights near Crater Lake Park,



Section of Boiler, Showing New Type of Hammer Cleaner in Use.

in southeastern Oregon, is the Natural Bridge over the Rogue river. It is located half a day's journey beyond Prospect, or Rogue River Falls, and is in the heart of the Upper Rogue Sugar Pine Reserve. The region abounds in ideal

NATURAL BRIDGE ON ROGUE RIVER, OREGON.

camping grounds, and each summer attracts hunting and fishing parties from all portions of the West.

The Rogue river here flows through a wide canyon, and at the point where the bridge stands lava rock was poured out profusely during the period when Mount Mazama was an active volcano—away back in the dim centuries long gone by. This lava is porous and honeycombed, but, instead of being washed away, was cut through beneath, thus leaving a natural bridge above. There are really two bridges, only a short distance apart. One is a low structure, rough on the surface. A wagon could not be hauled across it, though it is being used continually for horses, sheep, cattle, and pedestrians. The other bridge, shown in the accompanying illustration, is built upon perfectly constructed piers and arches, keyed and set as if put in place by human masons. Above the rock on this bridge, there is much soil, with growing hemlock, spruce, pine, and fir. This bridge spans a wild and turbulent stream, and is one of the natural wonders of the Sunset State.

A Dynamite Gun

AMONG the pieces of ordnance which have been tested at various times by the Government is what is known as the Gathmann dynamite gun. The claim made for this weapon was that it was the greatest engine of destruction in the world. It was planned and constructed to discharge a projectile which was to contain a charge of gun-cotton. The projectile might be called a "land torpedo," as it resembled a marine torpedo in shape and was thrown from the gun by the use of compressed air. The projectile itself consisted of an inner shell of steel filled completely with wet gun-cotton, separated from another charge of dry gun-cotton by a steel partition. The gun illustrated in the accompanying photograph has a caliber of 18 inches; and the inventor claimed that it would demolish the heaviest armor-plate which could be constructed. Tests made by the Government, however, indicated that when the missile struck the target its force was so distributed that but little impression was made on the target—in fact, less than that produced by the impact of a projectile from an ordinary gun of much smaller caliber. For this reason the gun was rejected by the United States Government for its service.

The experiments were made with the

[illegible]

enormous charge of [illegible] pounds of gun-cotton—as great a charge as is placed in large submarine mines.

We might note that up to the present but little practical success has attended the many attempts that have been made to adapt dynamite to use in projectiles. The experiments represent vast but so far apparently vain expenditures.

LEADING CURRENT ARTICLES

A Review of Articles of Special Interest Appearing in the Current Technical Press

Road Wheels for Mechanical Vehicles

WHEELS may be classed among the oldest of mechanical devices, and we have been so long accustomed to them that the importance of the part they play in all forms of traction is not generally appreciated. *Cassier's Magazine* (April) contains an article, by R. G. L. Markham, in which the author considers the various types of wheels in general use, and points out some of the conditions necessary for a perfectly satisfactory wheel. The first notable improvement in the construction of light vehicle wheels was the rubber tire, which was first made solid and cemented to the rim. Next came the introduction of pneumatic tires. These were adopted more for the sake of comfort than from necessity, but it is apparent that, without these, speeds would never have increased as they have. With the introduction of motor vehicles, inventors devoted most of their attention to the mechanism, and the wheels were largely ignored. We therefore find, especially in the case of heavy vehicles, that the wheels have not kept pace with the rest of the equipment. The writer lays down several general conditions which must be met in the construction of a satisfactory driving wheel for motor vehicles; and a number of different types of special wheels are analyzed, showing the extent to which these conditions are met. Some of the requirements in the case of wheels for very heavy vehicles, result in producing a wheel of rather remarkable proportions. According to some investigations carried on in London by a special committee, it was recommended that for a maximum axle load of 8 tons, with a wheel 3 feet in diameter, the width of tire should be about 10½ inches. It appears that the increase in diameter of the wheel has more effect than the width of tire in preventing damage to the road. The article concludes with descriptions of some novel types of very heavy wheels which have been used on various types of traction engines.

Proposed High-Speed Electric Railroad

A MODERN high-speed electric railroad proposed between Paterson, N. J., and New York, is described in the *Railroad Gazette* (March 17). The road will be double-tracked and rock-ballasted, and will have all grade crossings eliminated. It will run through Passaic, Rutherford, across the Hackensack Meadows, to Bergen Hill, from which point it will pass through a tunnel 4,900 feet long to its Weehawken terminal at the West Shore ferry opposite 44th Street. From this point, passengers will be taken to New York by the West Shore ferry-boats, and landed at either 42d Street or Franklin Street. The total length of the line will be 13.6 miles, of which three miles will be elevated, including portions in Passaic, Paterson, and Rutherford. This road will compete with the Erie, the distance by which would be 17 miles, and with the New York, Susquehanna & Western, over which the distance would be 26 miles. The cars will be of steel, operated by the third-rail system, similar to those used in the New York subway. It is proposed to run eight six-car trains per hour between 6 A. M. and 8 P. M. The time of express trains between terminals is estimated at 20 minutes; that of locals, at 30 minutes. The company has three corps of engineers in the field, and it is expected that actual work will begin within five months.

Car Lighting and Ventilation

THE *Street Railway Journal* (March 25) contains an interesting article on the subject of lighting and ventilation of

cars, by Mr. John P. Fox. These topics are of interest to almost every one, which is evidenced by the fact that in quite a number of cities laws have been passed regulating the ventilation of street cars. In England, much more attention has been paid to the question of efficient and artistic lighting of car interiors than in this country. The use of frosted lamps, colored shades, pear-shaped globes, and prisms, or cut glass globes, has proved to add materially to the quality of interior car lighting, and at the same time has proved an economy to the operating companies, for the reason that fewer lamps need to be used, and with better effect. As our electric cars grow more luxurious in their appointments, and as long-distance riding increases, refinements in the lighting system will not only conduce to the comfort of passengers, but will tend toward economy of current consumption for the cars. The question of heating and ventilation has always proved a difficult one, especially during extremely cold weather; and it is doubtful if any perfectly satisfactory scheme of heating and ventilating cars can be devised which will fill all requirements of travel during rush-hour. Electric fans are recommended as the only sure device if downward ventilation is desired, and the addition of one or two fans would not add materially to the complication of a modern car. Some experiments are quoted which go to show that it takes considerably less current to heat a car, if part of the heating current is diverted to a fan blowing outside air through the heaters. Some foreign car-ventilating methods are also described and illustrated.

Electric Power in Factories

Mr. A. W. Hesshaw has an article on this topic in *Electrical World and Engineer* (March 18). The principal advantage pointed out in the system described, is the ability to transmit power to great distances and to various localities, this making the system particularly applicable in case of an available water power in the vicinity, but at too great a distance for the mechanical transmission of power. Also, it is cheaper to generate power a long distance from the factory, even when coal is used, if the expense of getting the fuel to the factory is considerable, as in the case of metal mines. Another important item to be considered is the saving of waste power due to friction of belts, bearings, gears, etc. This friction loss in the case of mechanically driven shops, ranges from 20 to 60 per cent of the total power. Another advantage of the electric system is the ease with which individual control can be obtained, by throwing single generators or motors into the circuit as desired. The system also allows the omission of nearly all belts and shaft-hangers which are commonly used. Still another advantage is that the power developed by any motor can be measured with the greatest ease and with absolute accuracy; and, by use of the voltmeter and ammeter, or of a recording wattmeter, the factory manager can keep very close watch of what is being done. Various methods are employed for connecting a motor to the machine or shaft which is to drive, those most commonly in use being direct connection, gearing, belting, or the chain drive, depending upon conditions. In large factories, 440 to 550 volts is the potential most commonly employed; and in small factories, 220 volts.

Use of Pacific Coast Water Powers in Electrical Operation of Railroads

In the March issue of *The Journal of Electricity, Power & Gas*, Mr. Robert McF. Doble commences a discussion on this subject. The article was originally a paper read before the Pacific Coast Railway Club, and has been revised for the *Journal* by the author. The advantages of electrical over steam traction are discussed under three general heads—namely, advantages that appeal to the passenger, and which result in increased traffic; advantages relating to the operation of trains from a central station of power; and economies in first cost, maintenance, and operating expenses. In the course of the article, a comparison is made between a number of steam locomotives of different types and several electric locomotives which have recently come into use; and the author concludes that while the steam locomotive is fast

reaching the maximum limits of its possibilities, the electric locomotive is in its early stages of development, and notwithstanding its favorable comparison with the old-style locomotive, its possibilities have not yet been nearly reached. The author believes that the conditions in California are particularly favorable to the development of electrically operated railroads, for the reason that available water powers are distributed at frequent intervals all the way from southern California up into British Columbia. Only a very small portion of these water powers have been developed; but, even with the stations now operating, and the present transmission systems carrying power through the central part of the State, it is thought that at least some of the railroads could be profitably operated by electricity.

Parallel Operation of Dynamos

In the *American Electrician* (March), Mr. Lamar Lyndon discusses "Parallel Operation of Dynamos Having Different Characteristics." The matter of running several unlike compound-wound machines in parallel is very important, and this discussion throws light upon several rather hazy points. First, the method of adjusting the compounding by shunting the series-field of a single machine operating alone, is shown by means of a sketch. It is then explained—also by means of a sketch, and very clearly—why it is impossible to adjust compound-wound machines by means of series-field shunts when several of them are connected in parallel, because a shunt over the series coil of any one machine is in effect connected between the equalizer and, say, the positive bus bars, so that it forms a shunt across all the series coils. It is shown that the drop through any series winding must be the same as that of each of the others for any given load, regardless of size or capacity of machine. Therefore, in parallel operation, series-field shunts serve only to pass the generator current in excess of that carried by the series coil, and are in no sense voltage adjusters of individual machines with reference to others. A definite case is taken up, of paralleling several alternators having different characteristics, in which the proper drop to be allowed between the positive and the equalizer bus bars is determined.

New York's Fire-Protection Water System

Plans are now under way for a high-pressure water service for fire protection in New York's drygoods district, similar to the system now installed in Philadelphia and a few other cities. Details will be found in *The Engineering Record* (March 25).

At the present time there are about 80 fire engines in Manhattan and the Bronx, having a total pumping capacity of 20,000 gallons per minute. Within the area mentioned, it is proposed to lay mains and erect two pumping stations with a capacity of 30,000 gallons per minute, but capable of being increased to 48,000 gallons per minute. A good idea of the capacity of the proposed works can be obtained from these figures.

The stations will be entirely of fireproof construction, and of sufficient size for eight pumping units at each station. For the present, however, the system will consist of five units. The pumps are to be of the centrifugal, multi-stage type, direct-driven by electric motors. Each stage of the pump can increase the pressure about 50 pounds, and a six-stage pump is required for 300 pounds' pressure, this insuring a pressure of 250 pounds per square inch at the base of the hydrant.

The general piping scheme is to have 24-inch discharge mains leading from each station. These mains bound almost the entire area to be protected, and connect one station with the other. By frequent cross-connections, the water has to travel only a short distance through a main smaller than 20 inches before it reaches the hydrant from which it is to be drawn. Under the proposed plan the hydrants are always within 400 feet of any building in the district. There are sufficient hydrants, so that if any block were on fire, 60 streams of 500 gallons per minute each—or the equivalent capacity of 120 fire engines—could be concentrated on a block with a length of hose not exceeding 400 to 500 feet.

The system of mains has been so designed that it can be used for street-cleaning purposes, but special care has been exercised to avoid any reduction in the efficiency of the system from the fire standpoint. The street-cleaning hydrant is entirely separate from the high-pressure fire hydrant. The design of this hydrant is such that the supply of water will be cut off from it when the pressure in the main rises above about 70 pounds. This protection is necessary to prevent injury to the men in the street-cleaning gangs when at work sprinkling or flushing, if the pressure is suddenly raised without warning.

It is proposed to use telephone boxes similar to the system in use by the Police Department, so that a fire in any part of the district can be watched from at least one of them, and orders transmitted to the engineer at the pumping station regarding the requisite pressure and amount of water.

Line Construction for High-Pressure Electric Railroads

A PAPER from Mr. George A. Damon forms one of the most important items in the March *Proceedings* of the American Institute of Electrical Engineers. It includes a brief record of what has been accomplished in line construction, and a statement of the requirements and difficulties of operation in order to obtain permanent insulation at reasonable cost, safety to public, and reliability in service. The subject is divided under three heads—namely, moderate-speed and inexpensively equipped electric lines for country districts; high-speed interurban roads for service between large centers of population; electrification of steam roads. An interesting map is given, which shows at a glance the mileage of railroads in operation, under construction, and proposed. The details of construction of several high-pressure trolley roads already in operation, are discussed. The single-phase lines now in operation in this country have 3,300-volt trolleys, and it has been decided to use this pressure for several lines under construction. It is suggested, however, that it might be advisable to consider the use of a 6,000-volt pressure. For the electrification of steam roads a pressure of about 12,000 volts for the conductor wire seems desirable.

An Air-Resistance Dynamometer Car

THE Electrical Railway Test Commission appointed by the authorities of the Louisiana Purchase Exposition, has been conducting investigations in electric railroading for nearly a year. These investigations are described in *Engineering News* (March 23). Perhaps the most interesting of the tests are being made on the lines of the Indiana Union Traction Company.

This is a series of tests with a dynamometer car, in order to determine the resistance offered by the air to the motion of cars at high speed. To accomplish this, a special dynamometer car has been fitted up, consisting of a flat car mounted on double trucks, on which is placed an independent car body so mounted on wheels, which move on a track fastened to the flat car, that for practical purposes there is no friction between the car body and the flat car floor.

There is also a separate arrangement of the vestibule, so that experiments can be made with vestibules of different types. The resistance is measured by scale beams, and also by a spring balance; and it is possible to measure head and rear resistances separately. Besides measuring air resistance, the speed of the car and the direction and velocity of the wind are also determined very carefully.

The tests of the "Louisiana," as this car has been named, will be continued until sufficient data are at hand to determine the resistance of different shapes of car-front for all speeds reached by modern interurban cars up to 70 miles per hour.

New Ferryboats for San Francisco Harbor

THE demand for 15-minute ferry service between Oakland and San Francisco, a distance of three miles, has led to the contract for two ferryboats of a somewhat novel pattern, which are described in *Marine Engineering* (March).

One peculiar feature about these boats is that teams will not be carried, provision

being made simply for passengers. This has resulted in an odd arrangement of seats, as shown by the main deck plan. Extending along the center line of the vessel, will be a restaurant and galley and a barber shop, it being estimated that a man will have just about time for a shave during the passage. Experiments have shown that the smallest interval of time which can be allowed for in the slip, is about 3½ minutes; and, as there are only two of the boats, this makes it necessary that the trip should be made in from 10 to 11½ minutes. For accomplishing this result, the boats are capable of a maximum speed of 17 miles per hour, and of a very high power of acceleration.

There is one double-compound engine having two high-pressure cylinders 20 inches in diameter, and two low-pressure cylinders 42 inches in diameter, the common stroke being 28 inches. This engine actuates a shaft carrying a screw at each end of the ship. The working pressure is 160 pounds per square inch. Under these conditions, the revolutions would be about 150 per minute; and the indicated horse-power, about 2,000. The two boilers are Babcock & Wilcox type, designed for a working pressure of 200 pounds per square inch. The tubes are of 2-inch and 4-inch diameter. The boilers are fitted for burning fuel oil, which is carried in two tanks, as shown in the inboard profile. The combined capacity of the tanks is about 5,000 gallons. The oil is pumped to the furnace by a double pumping system, consisting of two Blake horizontal duplex pumps. Steam will be used for atomizing the oil.

The boats are lighted by electricity, generated by two direct-coupled sets having an output of 15 kilowatts at 110 volts.

De Forest Wireless Telegraphy

It is reported in the *Railway and Engineering Review* (March 18), that the large steel tower built and operated at St. Louis by the De Forest Wireless Telegraph Company will be erected on the grounds at Purdue University at Lafayette, Indiana. The tower, when ready for operation, will be under the direction of the professor of Telephone Engineering, who will use it for an elaborate series of experiments, among which will be the attempt to communicate with moving trains.

Business or a Profession?

Which Offers the Greatest Rewards to the Young Man To-day?

By DR. HENRY S. PRITCHETT

President, Massachusetts Institute of Technology

I AM ASKED whether a business or a professional career offers the greater rewards to a young man.

This question cannot be answered categorically. In business no less than in the professions, the stress of competition is becoming each year harder. To obtain in either a high place, requires ability, energy, and initiative of a high order. The man who has these qualities will get his reward, whether he choose one career in life or another, and the

From *Chicago Tribune*, December 11, 1904.

estimate as to which reward is the greater will always involve a large personal equation. There is no absolute standard of rewards.

The great bulk of men, however, possess these qualities in moderate degree only. For the average man, success in business will mean a modest living and a comparatively uninteresting life. Faithfulness and attention to business are not enough to get one further than a modest clerkship.

In the ordinary professions—the law, medicine, the Church—mediocrity means also a moderate reward. In such cases the choice of a profession ought to depend in some measure on the value of a man's work to the community.

Law and medicine contribute in the main to what one might call the passive side of production. They do not add to the wealth or the productive power of a nation. It must be my therefore that a man whose ability warrant no expectation of only moderate success in life may anticipate greater happiness, more interesting companionship, and a larger measure of usefulness in the world by entering a profession which contributes positively to the power or wealth of a nation. Such professions are those of the engineer, the architect, the chemist, and the teacher. In these moral efficiency will count as much as in the others.

There are few men, however, who have the clearness of vision to look themselves in the face and admit their mediocrity. Such ability would argue a mind of such rare quality as to put him out of the class of the average.

Dinner-Pail Philosophy

¶ Great thoughts follow any labor.

¶ The sun shines for all—who get up early.

¶ Love gives us leave to dispense with courtesy.

¶ Any man can make a fool of himself by trying to act smart.

¶ We have all heard of the man who was killed by kindness—but the proof is lacking.

¶ In Adam's day, woman was merely a side issue, but at the present writing she is pretty much the whole show.

¶ There are periods in almost every man's career when he would rather have a lie told about him than the truth.

¶ Our real measure of ability and willingness is in our doing the little that we can do, and not the great deal that we would like to do.

¶ The [illegible] asters.

¶ There are [illegible] looks at [illegible]

¶ Love of [illegible] price.

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27

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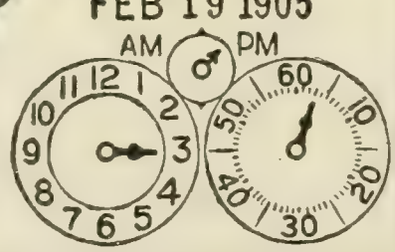
What your labor on a job costs *cannot be over-estimated.* The use of the Perry Time Stamp in recording the *exact* time of commencing and completing each operation enables you to arrive at facts with minimum effort.
Ask for particulars concerning WORKING DAY DIALS. They eliminate 90 per cent. of the figuring.
The only portable, automatic self-inking Time Stamp made.

Write for FREE Booklet.

The Business Man's Time Saver.



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11 W. Madison St.
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PERSONAL AND MISCELLANEOUS

Royalty Interested in American Correspondence School Work

THE growth of the American correspondence school idea has been little short of marvelous. Born in indifference and ridicule, nursed in prejudice, this phase of educative effort has lived to take its place in the general scheme of American education, recognized not only by all broad-minded educators at home, but even by royalty abroad. The following clipping recently appeared in the Waikato (New Zealand) *Times:*

A correspondent sends us the following interesting and pleasing item of information taken from a Spanish contemporary:

"His Majesty the King is taking a deep interest in electrical science, and is giving attention to correspondence study of the American School of Correspondence at Armour Institute of Technology, Chicago, United States of America. Matters electrical are backward in all Spain, and the King has the desire to advance our country and assist it in recovering its position amongst the nations. He is therefore acquainting himself with the latest American advancements in electrical engineering."

Recently Graduated

THE following students have been graduated from the American School of Correspondence since the April number of THE TECHNICAL WORLD was issued:

Appleton, Chester L., Mount Holly, N. J.—Course: Stationary.

Backus, Harry F., Cleveland, Ohio—Course: Electrical.

Beard, Norton S., Holton, Kan.—Course: Electrical.

Bergner, W. G., Peoria, Ill.—Course: Plumbing and Gasfitting.

Clark, Ralph C., Poy Sippi, Wis.—Course: Engineer's.

Jurs, Henry C., North Collins, N. Y.—Course: Electrical.

Keppel, Thomas, Zeeland, Mich.—Course: Refrigeration.

Kime, Ralph V., Kendallville, Ind.—Course: Mechanical Drawing.

Lockney, Ira L., North Fond du Lac, Wis.—Course: Stationary.

McDonald, Donald, Chicago, Ill.—Course: Electric Lighting.

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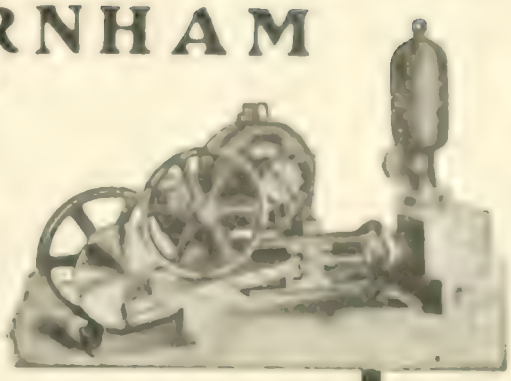
DIRECT STEAM, BELT DRIVEN
and
ELECTRIC

PUMPS



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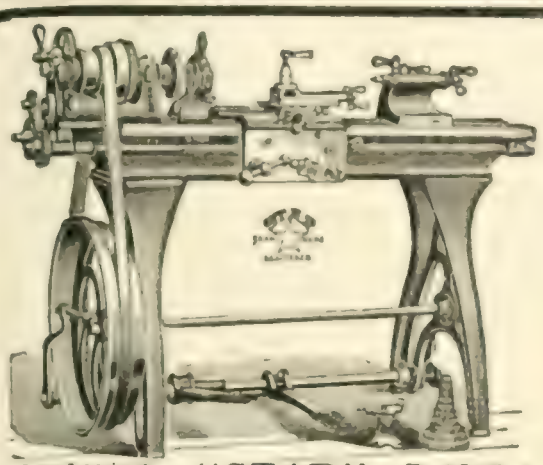

9 and 11 inch "STAR" Foot Lathes
9, 11, 12, 14 inch "STAR" Power Lathes

"Star" Lathes Foot and Power...

High grade screw cutting engine Lathes, with [illegible] steel bronze spindles, phosphor bronze bearings, quick driving reversing feeds with [illegible] drive to apron, patented spring nuts which allow quick shift of chasers, gears, etc. Drawing Chuck, Countersinking, Milling and Taper Attachments if desired.

Suitable for electrical and repair work, model makers, gunsmiths, technical schools and toys, accurate, up-to-date shop and tool room service. Ask for Catalog G.

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RECOMMENDED FOR 800 LBS. STEAM WORKING PRESSURE
TESTED TO 2000 LBS. SQUARE INCH HYDRAULIC PRESSURE

We carry in stock a complete line of heavy hydraulic valves, fittings and pipe, suitable for pump columns in mines, long pipe lines, etc.

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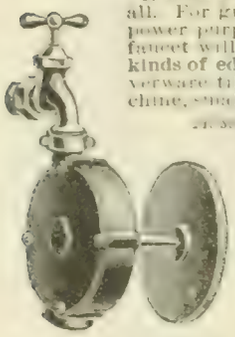
WARNER
"LITTLE WONDER" WATER MOTOR



A boon to the household: A time and money saver for all. For grinding and sharpening, polishing and light power purposes. The "Little Wonder" attached to your faucet will grind and sharpen knives, scissors and all kinds of edged tools. Will polish your cutlery and silverware till it shines like new. Will run a sewing machine, small dynamo or other light machinery.

Absolutely practical. Universally successful. 25,000 in use all over the world. Motor attaches directly to any water faucet, smooth or threaded, and can be detached from faucet in an instant. Connection for smooth faucet 35 cents extra.

Outfit complete, including Emery Wheel, Buffing Wheel and Pulley packed in neat wooden case - - - **$4.00**

We also carry a full line of larger motors from ½ to 10 horsepower, and water desk and bracket (wall) fans of exclusive merit.

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Free Booklet describing the "Little Wonder" on request.

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MANUFACTURERS OF
Crucible Sheet Steel
of superior quality, for Circular Saw Plates, Cross-cut, and all long Saws, Billet Web, and all short Saws; also Rollers of Dead Soft and Three-Pass Cold-Rolled Sheets.
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in the rough or partly finished, for the half horse power
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Castings, Materials and Blue Prints, complete, $16.50. Horizontal and Upright Types. Send for Circular 7.
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Solve the *smoke nuisance* problem. Are in *compact* form, *clean* to handle. Have complete combustion. Are easily and cheaply made by *our* machinery from practically inexhaustible peat bogs.
Write for descriptive literature and special investment offer.
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PERSONAL AND MISCELLANEOUS (Continued)

Melvin, Thomas, Bowling Green, Mo.—Course: Electrical.

Moyse, Vittorio, Milan, Italy—Course: Electrical.

Taylor, J. W., Agricultural College, Mich.—Course: Electrical.

Turnbull, Gustave, Jalapa-Vera Cruz, Mexico—Course: Electrical.

Estimates Wanted

THE City of Central Falls, R. I., is contemplating the erection of a municipal lighting plant, and wishes to receive estimates of the probable cost of such a plant. It has a population of about 20,000 in an area of about a square mile, and a total property valuation of about $9,000,000. A copy of the plan of the city, drawn to scale, and giving the location of lights, poles, etc., will be mailed on application to the Clerk of Committee on Municipal Lighting Plant, William H. Goldsmith, Central Falls, R. I.

Iowa Automobile Law Tested

THE trial of United States Commissioner F. M. Hunter of Ottumwa, before Justice of the Peace W. W. Wiley, near Birmingham, Iowa, for an alleged violation of the automobile law, resulted in an acquittal. The case against Commissioner Hunter was the result of an accident which occurred on the public road last November, when a horse driven by F. L. Small, a farmer living near Birmingham, became frightened, and ran away upon meeting a Rambler automobile owned and occupied by Mr. Hunter, though another person was operating it. Immediately after the accident, Mr. Small, by letter, demanded payment of $100 in settlement of alleged damages sustained, and later an attorney made a similar demand. Payment was refused, and Mr. Small filed a complaint charging Mr. Hunter with violating the law by having failed to stop his machine, and also by not assisting in the handling of the frightened horse.

The action was brought under Section 9 of the act regarding the registration of motor vehicles and regulating their use and operation on the public highways, which became effective July 4, 1904. From the evidence, it appeared that at the

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OLDS ENGINES

ECONOMICAL POWER

In sending out their last specifications for gasoline engines for West Point the U. S. War Department required them "to be Olds Engines or equal." They stood all others or the U. S. Government would not demand them.

They are the horizontal type, 2 to 100 H. P., and are so simply and perfectly made that it requires no experience to run them and

Repairs Practically Cost Nothing.

Send for catalog of the Wizard Engine 2 to 8 H. P., Spark Ignition Gasoline Engine, the same as is furnished Submarine "A." The most economical small power gasoline engine made, either with water pump jack or direct connected pump, for all general pumping, power and lighting plants.

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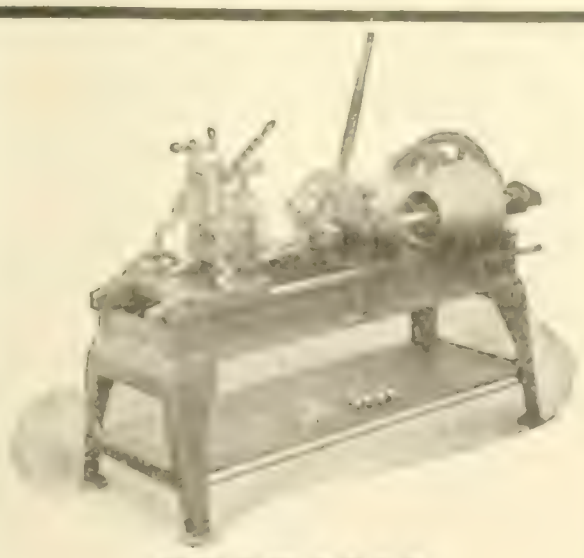

PEERLESS DIE HEAD QUICK CHUCKING DEVICE

No stopping of the machine for gripping or releasing the pipe. No backing out of the thread. There are other special features.
Send for full description.

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Builders of Improved Pipe Cutting and Threading Machinery
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Do you run your plant without an indicator? If you do you are losing money. The [illegible] would insist upon having an indicator, as it is your guide and only means of measurement between steam knowledge and steam ignorance.

An Indicator will more than pay for itself every month. Purely as a matter of business it is a necessity—for by its daily use you can get good indications as to increase profits.

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with the [illegible] attachment, you do not have to take any pressure of steam without stopping or disconnecting. This Indicator [illegible] more tailored yourself about it and you will see why, and why it is the cheapest.

Take the matter NOW to heart, and the vital question—[illegible] saved and dollars made.

Special prices to [illegible] and a pamphlet telling you all you [illegible] Indicator, which gives full and explicit information about the attachment and use of the Indicator—the only means of steam [illegible] number.

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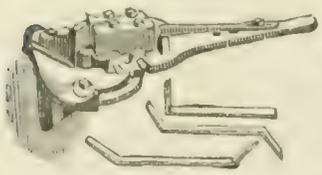

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We make hand-power-benders for forming angles in stock 1 inch thick and under. Light stock can be bent cold.

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Fan Motors	$2.00 to $15.00
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Telephone, complete	2.50, 5.95
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Electric Carriage Lamps	5.00
Electric Lanterns	2.00, 3.00
$8.00 Medical Batteries	3.95
$12.00 Belt with Suspensory	2.50
Telegraph Outfits	2.00
Battery Motors	75c to 12.00
Battery Fan Motor	6.50
Bicycle Electric Lights	3.50
Electric Railway	3.25
Pocket Flash Lights	1.00 to 2.50
Necktie Lights	90c, 1.00, 1.25
Dynamos	$2.00 to 900.00

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Agents Wanted. Send for New Catalogue Just Out.
Our Battery Fan Motors are most economical.

ANYTHING MECHANICAL IN ANY METAL.
LET US ACT AS YOUR FACTORY.
THAT IS OUR BUSINESS.

We are the originators of
"Let us Act as Your Factory"
Therefore if you see it used in connection with advertising of firms in our line, we hope it will promptly bring to your mind
"The Michigan Novelty Works"
We have made this phrase valuable and consider its use by others as
"Unjust Competition in Trade"
It stands for everything that will make possible your success. It guarantees those conditions upon which depend your Financial and Commercial Success.

A Failure attracts no attention,
(I told you so is the usual remark).
A Success—has many Imitators.
Therefore when you read:
"Let us Act as Your Factory"
"Let us be Your Factory"
Remember,

MICHIGAN NOVELTY WORKS
126-136 Rose Street, - - Kalamazoo, Mich.

time of the meeting of the parties, Mr. Small alighted from his buggy and, taking the horse by the reins, led him toward the machine, at the same time motioning to the occupants. The horse showed no sign of fright, so the operator of the car continued to drive it slowly forward until within about three rods of the horse, when Mr. Small again signaled, and the machine was brought to a stop. Just as the machine was stopped, the horse, for the first time, appeared frightened and dashed into the fence at the side of the road; then, jumping back, he broke loose from Mr. Small and ran away. The fact was established that Mr. Small's property sustained no damage, nor was he injured in the least. Mr. Hunter was discharged without offering any evidence or making any arguments in his behalf. The Justice, who is a young farmer, rendered his decision without any comments, his holding being that the law had not been violated.

Novel Industrial Beneficial Association

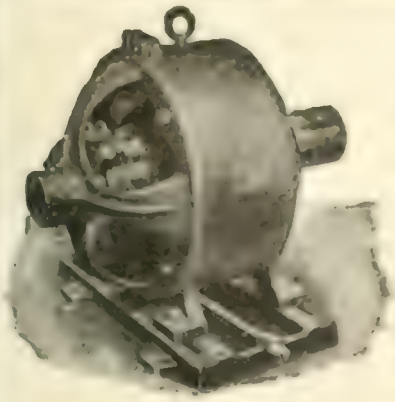
THE shop employees of the Crocker-Wheeler Company, electrical manufacturers, at Ampere, N. J., have organized a Beneficial Association which has a number of novel features.

Every employee who pays ten cents a week to the Association will be entitled to $10.00 a week, for twenty weeks, during incapacity through illness. If he dies, his family will receive $100.00. The payment of 20, 30, or 40 cents a week entitles him to $15.00, $20.00, or $25.00 respectively, with death benefits of $150.00, $200.00, or $250.00.

The Company has offered to contribute an amount equal to the dues paid to the Association. Thus, if $6,000.00 is paid yearly in dues, the income of the Association will be $12,000.00. The Company does not require representation in the Association, which will be run entirely by the employees.

The results of this experiment will be watched with great interest by all who are concerned with the problems of labor or with sociological questions. It will constitute an object-lesson of immensely important bearing, possibly affording a model which other corporations may find it advantageous to follow.

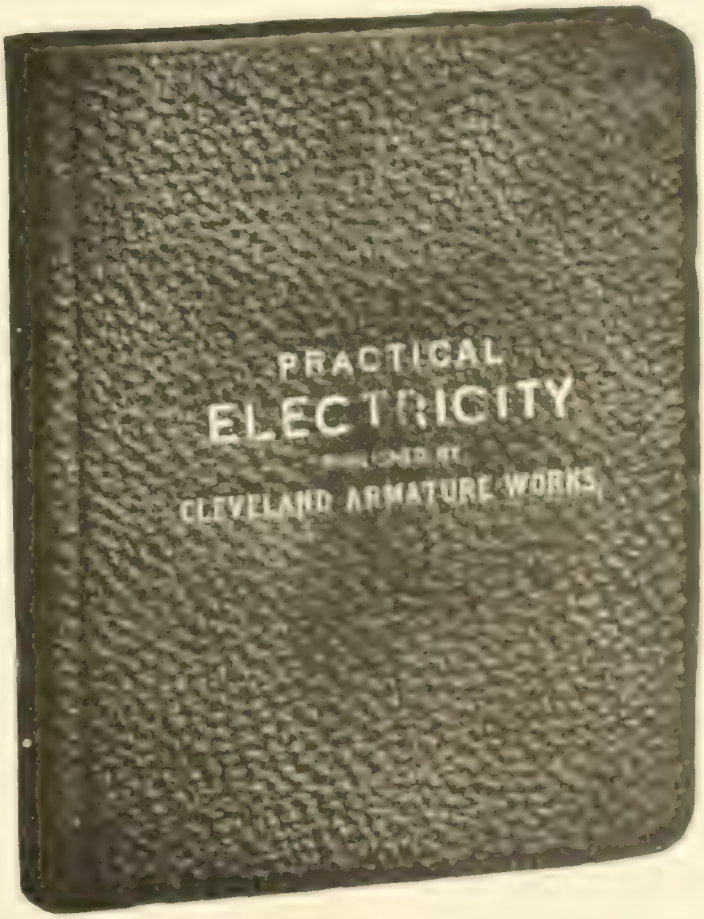
HOW ONE THING LEADS TO ANOTHER



From our paper, THE ARMATURE WINDER, issued for the purpose of advertising our facilities for repairing electrical machinery, originated our book, PRACTICAL ELECTRICITY, which has proven to be the most popular book devoted to the study of electricity: 12,000 copies have found buyers, and the Fourth Edition is now ready. From PRACTICAL ELECTRICITY has sprung the manufacture of Dynamos and Motors.

By buying a copy of this book and becoming familiar with the art of electricity you don't know what it may lead up to.

There are XX chapters or subjects carrying you from the fundamental principles of electricity on through the various branches to a point where the careful student comprehends the complete designing, care and operation of a dynamo or a motor. Each subject is carefully written and to the point. After a student studies a subject, he is questioned on that subject in such a manner as to bring clearly to his mind the points he needs to know regarding same. A DICTIONARY in back of book will enable him to learn the meaning of any electrical word, term or phrase used in this book as well as hundreds of others in common use. All required tables necessary in the study are in it.



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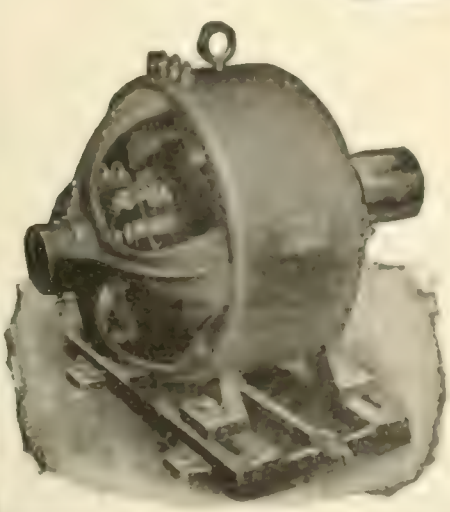
While reading elementary from our book and performing experiments in electrical engineering, you will be engaged in the solution of any difficulties encountered and gaining a good knowledge.

Write for our catalogue and particulars in reference to how to sell, and remember we lend.

Our proposition is an ideal one for any person who is interested in a power plant or electric station; the profits to users, who furnish power will in some cases, have you. If not, we will show you we have for a good thing.



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This book will help you in the study of electricity as no other book ever has. ¶ The offer we make of refunding money if book is not satisfactory upon examination is AN UNUSUAL ONE in connection with the sale of a book. But we have no fear of its return. Your decision will be what thousands of others' have been. Many would not buy it if it could not be returned. We would print testimonials by the thousands. It is the best to order and be your own judge of its merits.

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The ideal way to operate a typewriter is by the **Touch Method** (without looking at the keys). When a typewriter is so operated the operator can give undivided attention to the copy to be transcribed, and acquire marvelous speed.

The Fox Typewriter is recognized as the best adapted for this method of operating. The compactness of the keyboard, the short key dip, the light touch (25% to 50% lighter than any other), are perfected features in the Fox and give it a great advantage over all others.

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By a special arrangement of the escapement the operator can instantly change the speed of the machine from "regular" to "fast," so that any Fox Typewriter is adapted to the speed of the operator, a wonderful advantage where speed is any consideration, and one not found on other typewriters.

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Can be used when desired, and by simply touching a button, credits or special notations can be inserted in a different colored ink from the body of the letter.

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We are proving this assertion every day. We want an opportunity to prove it in your office, and we are willing to undertake it without any expense to yourself.

Our catalog describing the machine in detail will be sent free upon request.

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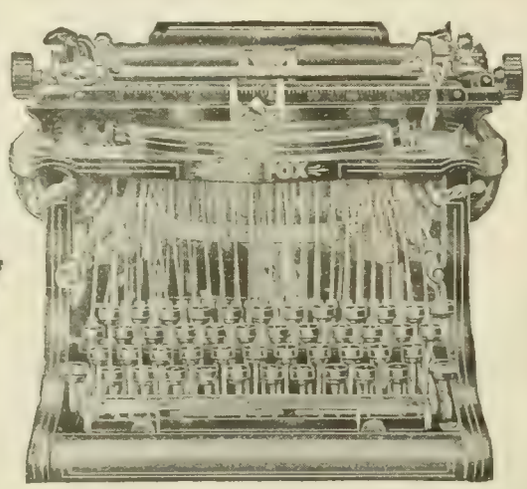

CONSULTING DEPARTMENT

Steam and Coal Required to Heat Water

Questions: 1. What is the best and most economical method of heating 200,000 gallons of water from initial temperature of 40° to final temperature of 200°? Water to be used for washing purposes in factory.

2. If heated by fire, how much grate surface will be required?

3. If heated by live steam, how many horse-power and what pressure will be required?

4. If heated by exhaust steam at atmospheric pressure, what engine horse-power will be required?—*J. H. M.*

Answers: 1. Since one gallon of water weighs 8.3 pounds, 200,000 gallons of water are equivalent to this number times 8.3 pounds. Since the rise in temperature is 160°, the number of heat units that must be supplied is $200{,}000 \times 8.3 \times 160$. As to the most economical method of supplying this heat, it depends upon the available sources. It is common practice to use exhaust steam for such purposes; and, if such is available, it can be conveniently led to coils which may be placed in tanks containing water. Since exhaust steam is frequently allowed to escape to the atmosphere, this method would seem to be the most economical, as it requires no additional fuel.

2. The water can of course be heated directly in a boiler; but it is impossible to state the grate surface required, since you have not stated the time allowed for heating this water. We may allow 8,000 heat units for each pound of coal burned; so that, by dividing the quantity of heat found above, by 8,000, the pounds of coal required can be found. The size of the grate will then depend upon the rate at which the coal is burned; and this may vary anywhere from 4 to say 20 pounds per square foot of grate per hour. Assuming the smaller rate, the grate surface (in square feet) must be:

$$\frac{200{,}000 \times 8.3 \times 160}{4 \times 8{,}000}.$$

If the greater rate is assumed, then the surface will be just one-fifth of this.

PATENTS

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During the past ten years Mr. Shepherd, of Shepherd & Parker, has entered for me a great many important patents. We have no hesitation in heartily recommending him to anyone having need of the services of a patent attorney.
HALL WORLD CASH LAUNDRY CO.

Mr. Parker on November 1, 1905, resigned his position as an Examiner in the U. S. Patent Office to enter this firm.

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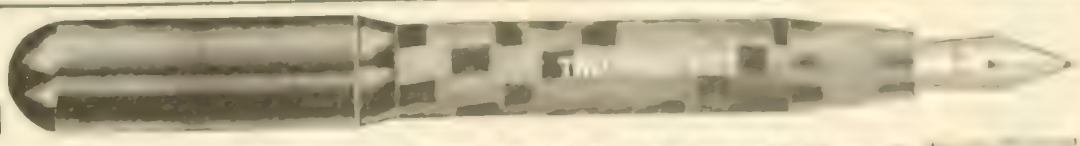

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CONSULTING DEPARTMENT—(Continued)

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3. In round numbers, one pound of steam will give up 1,000 heat units on condensing. Dividing the heat units first determined, by 1,000, the pounds of steam required will be found. This gives:

$$\frac{200{,}000 \times 8.3 \times 160}{1{,}000} = 265{,}600 \text{ pounds.}$$

Since about 30 pounds of steam are equivalent to one horse-power, dividing the total quantity of steam by 30, we have the horse-power:

$$\frac{265{,}600}{30} = 8{,}850 \text{ H. P.,}$$

if heated in one hour. If 10 hours' time is allowed, then,

$$\text{H. P.} = \frac{8{,}850}{10} = 885.$$

4. Probably 30 per cent of the exhaust steam will be moist, so the actual horse-power of the engine should be about 30 per cent greater than the calculations would indicate. In case, however, the engine uses less than 30 pounds of steam per horse-power hour, its rated power must be greater in proportion.

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Question: I should like some definite information as to what the wiring requirements are for Marine work. Is there a standard like the National Code, or is the practice still an unwritten code that has been developed by experience and hard knocks?—*R. D. C.*

Answer: In the National Electrical Code, at the back, there is a section devoted to Marine work, which takes up the special requirements for this class of wiring, giving the requirements in regard to generators, running of wires, switchboard work, resistance boxes, switches, cut-outs, etc. If, therefore, you will look up this reference, you will doubtless find the information you desire.

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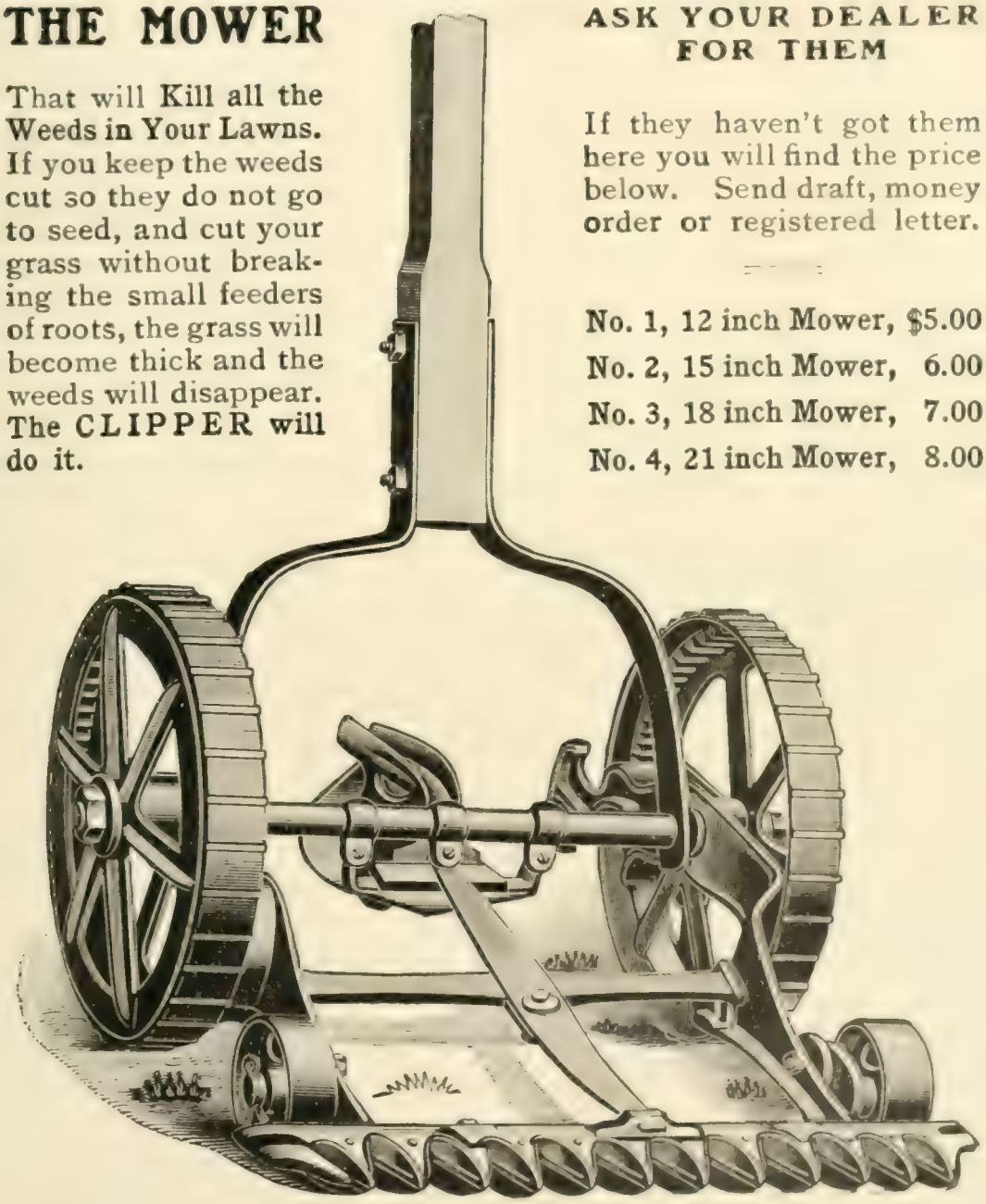

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CONSULTING DEPARTMENT—(Continued)

Single-Phase Motors

Question: Will you kindly explain the principles of operation of a single-phase alternating-current non-synchronous motor?—*S. J. H.*

Answer: When a polyphase induction motor is once started and running at full speed, all the phases but one may be disconnected from the primary member, and the machine will continue to operate and carry a very considerable load, say two-thirds as much as when all the phases are connected to the supply mains. An induction motor, however, will not start when one phase only of its primary member is connected to single-phase supply mains. Therefore, when it is to be driven from single-phase mains, special provision for starting must be made. An induction motor designed to operate from single-phase mains, and provided with special arrangements for starting, is called a "single-phase" induction motor.

Three methods of starting single-phase motors are in general use, as follows:

(*a*) HAND STARTING. Very small induction motors may be started by giving a vigorous pull on the belt which connects the motor to the machinery which it drives.

(*b*) SPLIT-PHASE STARTING. When an alternating current is divided between two branches of a circuit, there is a phase difference between the currents in the two branches, if the ratio of resistance to reactance is different in the two branches. This is especially true if one branch contains a condenser. Now, a two-phase motor will start when the currents in the two stator circuits are less than 90 degrees apart in phase, although the starting torque grows less and less as the phase difference of the two currents decreases. The dephasing of the two parts of a single alternating current in two dissimilar branches of a given circuit, is called "phase-splitting;" and a single-phase induction motor may be arranged to start as a two-phase motor, by splitting a single-phase current, and using the two parts of the split current exactly as one would use two genuine two-phase currents.

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7. What are the general qualities of heat?
8. Are we able to transfer light into heat?
9. What heat is developed by compression of aeriform bodies?
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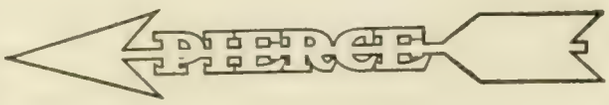

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slots. The other set of coils consists of fewer turns of fine wire occupying the remaining slots. The first set constitutes the "working coils;" and the second, the "starting coils." After starting, both sets of coils are connected to the single-phase supply mains; and the difference in the resistance and reactance in the two sets of coils splits the single-phase current supplied, sufficiently to give a slight starting torque.

In small General Electric single-phase induction motors, there is a condenser provided, which is connected in series with one phase (the starting coils) of the stator windings in order to give something approaching 90 degrees' phase difference between the split-phase currents. A condenser for a given volt-ampere capacity can be constructed much more cheaply for high than for low voltage. Therefore the condenser-compensator made by the General Electric Company is provided with a small step-up transformer (auto-transformer) so that the condenser may be designed for high electromotive force.

(*c*) Repulsion Motor Starting. If an ordinary direct-current dynamo were provided with a laminated field magnet, and if its field magnet were excited by an alternating current, currents would be induced in the armature windings by the alternating field, provided the brushes of the direct-current machine were set at an angle of about 45 degrees (for a two-pole machine) from their proper position for collecting a direct current. These currents induced in the armature would be acted upon by the alternating field so as to produce a torque which would cause the armature to rotate. A self-starting single-phase alternating-current motor constructed on this principle is called a "repulsion" motor.

The Wagner single-phase induction motor is of the repulsion type. The iron stator core is very much like the core of an ordinary induction motor—namely, in the form of a laminated ring closely surrounding the armature and slotted on its inner face. The armature is of the ordinary direct-current drum type provided with a disc commutator with radial commutator bars. For a 4-pole machine, four short-circuited brushes

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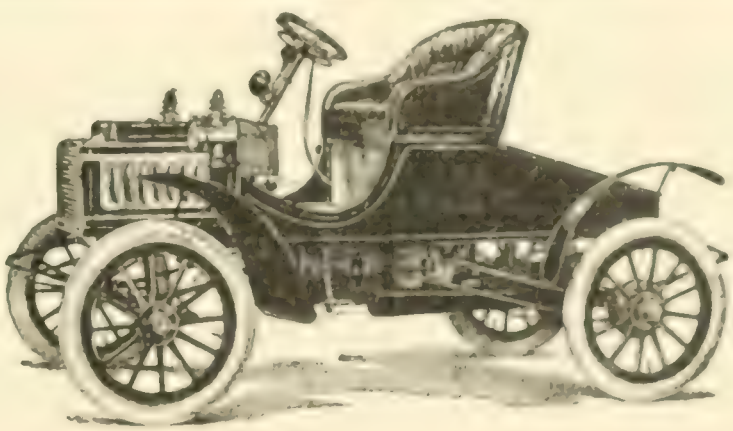

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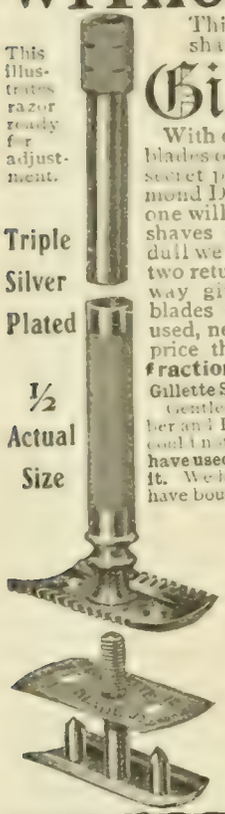

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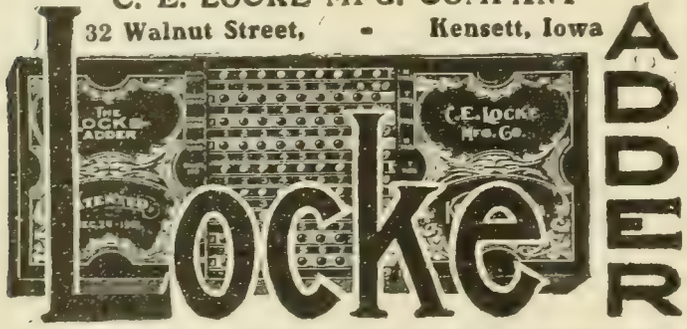

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CONSULTING DEPARTMENT—(Continued)

are pressed against the face of the disc-shaped commutator at angles of 90 degrees. At starting, the stator winding is connected to the single-phase supply mains, and the machine starts as a repulsion motor. Inside the armature are two governor weights, which are thrown out by centrifugal force when the machine reaches full speed, thus pushing a solid copper ring into contact with the inner ends of the commutator bars, completely short-circuiting the winding. At the same time, the brush-holder is pushed endwise, lifting the brushes off the commutator.

Pressure in Steam Mains

Question 1: In heating a group of buildings by steam from a central plant, the steam mains being laid underground and some of them ½ to ¾ mile long, which is best—to carry boiler pressure (90 lbs.) from central plant to each building, and there to reduce, say, to 10 lbs.; or to carry 10 lbs. directly from boiler plant in mains? Why?

Question 2: What is the best method of protecting underground steam pipes, other than by brick conduit?—*T. M. D.*

Answer 1: Of the two methods of running the steam, we should suggest that it would be more economical to carry the high pressure, 90 pounds. The principal losses are due to radiation and friction. Using the proper sized pipe in either case, the loss due to friction of flow should be equal to about one-fifth of the loss due to radiation when the sum of the two is a minimum. Now, if the steam were transmitted at the lower pressure, it would require a pipe about twice as large, consequently there would be more loss by radiation. This increase would probably be 30 per cent over the loss at the higher pressure. The decrease in loss due to friction when we use the larger pipe, is about in the same proportion—that is, one-third of what it was at the higher pressure. Since the total loss due to friction, however, is only one-fifth of the total heat loss, the decrease due to friction is not so great as the increase due to radiation. Consequently there is a net loss at the lower pressure. Further, the cost of the pipe will be less at high pressure, since the smaller sized pipe can be used; but this is partly counterbalanced by the in-

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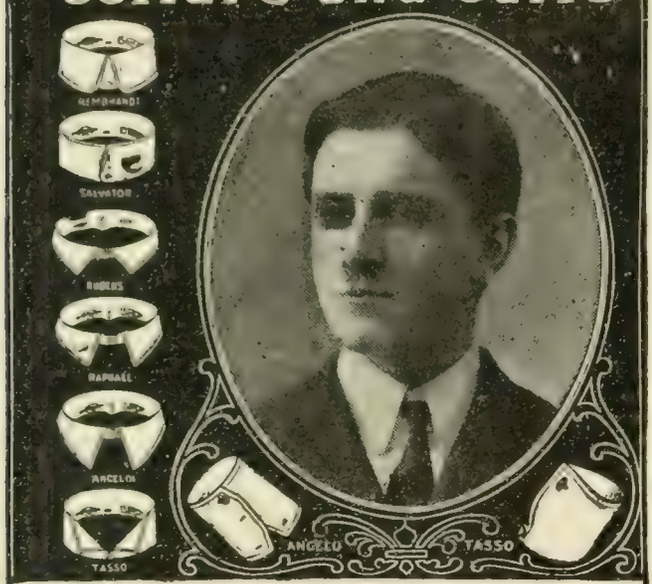

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Answer 2: Other than the method of running the pipe in conduits, a wooden tube with a concentric air space surrounding the pipe is desirable. This system, however, is objectionable, because it does not protect the pipe from ground water. A modified form in which both the steam and return pipes are covered with asbestos and hair felt, and placed in a box made of two-inch plank, has been employed with success. The loss in pipes protected as above should not exceed 20 per cent of the loss in the case of bare pipes.

Commutator Segments—Flashing

Question 1: Why is there an odd number of segments in a commutator of an exciter or motor, while dynamos have an even number?

Question 2: What causes a direct-current series-arc machine to flash when the circuit is broken?—*P. L. P.*

Answer 1: There is no such sharply drawn distinction as you suggest between the number of segments on a motor or exciter and that on a generator. The number of commutator segments in any case will depend upon the class of winding, and not on whether the machine is used as a generator or motor. An exciter is itself a generator; so, naturally, there can be no distinction whatever between a generator and an exciter.

Answer 2: The flashing is caused by the rise in voltage in the armature. If the circuit is broken, the controller throws the brushes back to the full-load position, thus generating a very high voltage.

Fault in Voltmeter

Question: Will you please tell me what may be the reason that an electrostatic voltmeter will not show a steady voltage after the alternator reaches about one-quarter load, but is perfectly steady below this load? The lights show no variation in brilliancy, and another voltmeter of exactly the same type shows a steady voltage.—*A. C. B.*

Answer: You will probably find that the charged plates, for some reason or other, are beginning to lose their charge. This is very likely due either to leakage or to static discharge. In other words, your voltmeter is defective.

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Laboratory and Factory Tests in Electrical Engineering. By George F. Sever, Adjunct Professor of Electrical Engineering, Columbia University; and Fitzhugh Townsend, Tutor in Electrical Engineering, Columbia University. Pages 236. Cloth, 6 by 9 inches. Illustrated. Published by D. Van Nostrand Co., New York, N. Y. Price, $2.50 net.

THIS book is intended for the advanced student in electrical engineering, as a considerable knowledge of fundamental principles is assumed on the part of the reader. The subjects treated represent the laboratory work required in the Electrical Engineering course at Columbia University, and are intended as a textbook for the use of students. It is believed, however, that this volume will be found useful also to those who are practically engaged in the profession of electrical engineering. As its title implies, the book prescribes a large number of laboratory and factory tests on various kinds of electrical machinery and apparatus, each test being accompanied with brief theoretical discussions of the theories involved. The experiments are divided into three general classes—namely, direct-current tests, alternating-current tests, and electrical measurements. From twenty to thirty different tests are given under each of these general headings; and many of the tests are of a practical kind, which the student, later on, will find of material value in his professional work.

Alternating-Current Testing. By Fitzhugh Townsend, Tutor in Electrical Engineering, Columbia University. Pages 32. Paper, 5 1-2 by 8 1-2 inches. Illustrated. Published by D. Van Nostrand Co., New York, N. Y. Price 75 cents.

THIS pamphlet gives an outline of the course in alternating-current laboratory work used by the graduating class in Mechanical Engineering in Columbia University. It includes some of the usual commercial tests, and a number of experiments illustrating some of the characteristic features of this class of ma-

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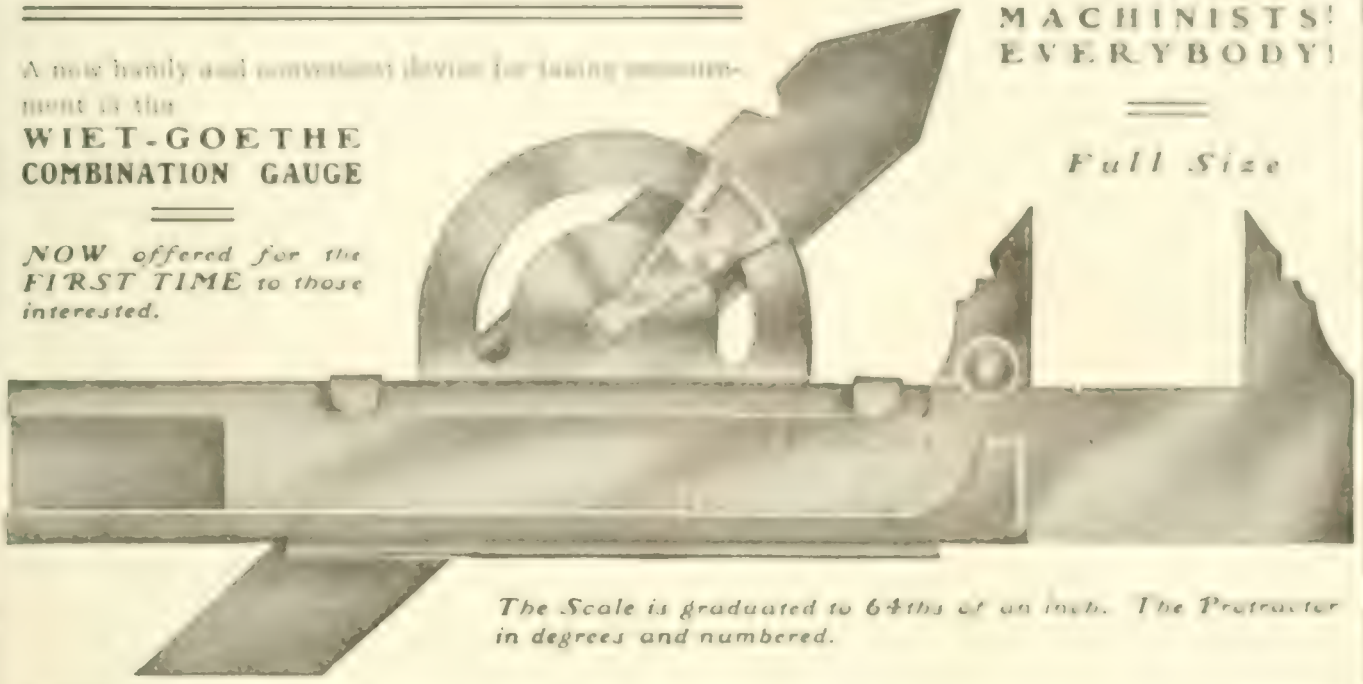

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LITERATURE—(Continued)

chinery. As the subject is treated in a practical way, the pamphlet will undoubtedly be of value to those dealing with alternating-current machinery who have only a limited knowledge of the subject.

Brookes Automobile Handbook. By L. Elliott Brookes. Pages 320. Flexible Leather, 4 1-2 by 6 1-2 inches. Illustrated. Published by Frederick J. Drake & Co., Chicago, Ill.

THIS handbook is intended as a practical guide for the use of automobile owners and operators. It contains general descriptions of all the parts of electric and gasoline machines, and general directions for operating, repairing, and testing them. As a large number of subjects are covered in a comparatively brief space, the information contained is condensed. The work is well done, the subjects in general being treated in a practical rather than a theoretical way. The book is evidently intended to guide the operator in the care of his machine and to point out the most common troubles and their remedies. Instead of an index being supplied, the subjects are arranged alphabetically, as in an encyclopedia; and while the continuity of the work is thus destroyed for the general reader, it constitutes a handy form for reference purposes.

Electricity Control. A Treatise on Electric Switch Gears and Systems of Electric Transmission. By Leonard Andrews. Pages 230. Cloth, 6 by 9 inches. Published by Charles Griffen & Co., Limited, London, Eng., and J. B. Lippincott Co., Philadelphia, Pa. Price $3.75.

THIS book opens with the general principles of switch-gear design, pointing out the importance of simplicity, the necessity of non-combustible construction, the importance of accessibility and standardization, and other general features of switch gears. The apparatus considered is the larger sort found in central stations, and used between the generators and the distributing center; and, on account of the infinite variety of small apparatus, no attempt has been made to consider the latter. The details of the construction of a large number of the devices are explained, and the respective advantages and disadvantages of differ-

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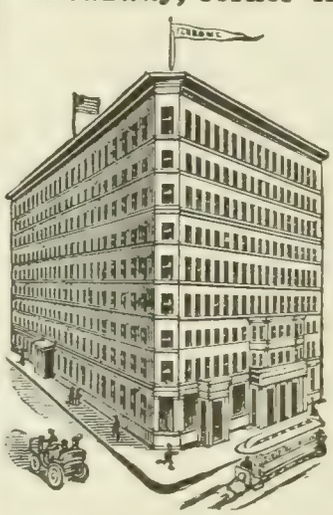

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CATALOGUES

Brown & Sharpe Manufacturing Company, Providence, R. I. Catalogue (1905) of Machinery and Tools. Pages 494. Paper, 3 1-2 by 5 3-4 inches.

THE 1905 edition of this catalogue has been thoroughly revised and somewhat enlarged. The new matter, together with the changes from the old edition, makes it desirable to obtain this new edition, which will be mailed free to any address upon application. The catalogue contains a large number of tables and a great deal of general information, which makes it very valuable to the workman as a book of reference. Its contents cover a very large variety of machines and small tools which this company manufactures, and the new features are printed on colored inserts so they can readily be distinguished.

The Guarantee Electric Company, Chicago, Ill. Catalogue entitled "As the Photographer Saw Us." Paper, 7 by 11 inches.

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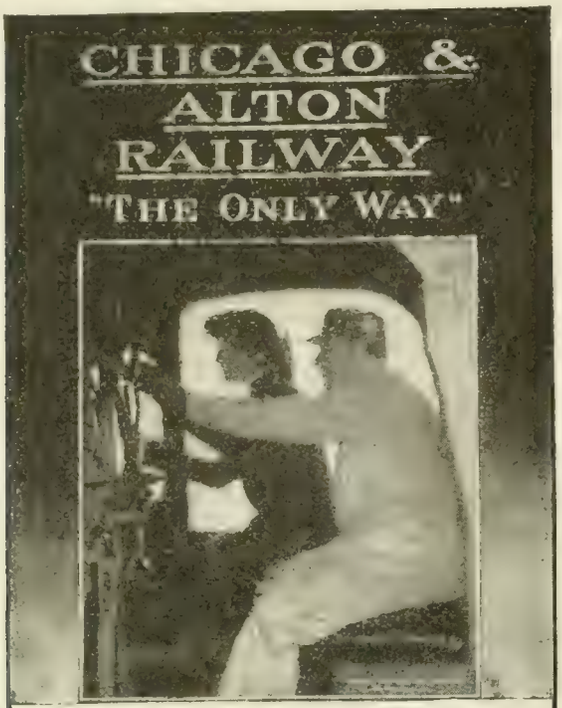

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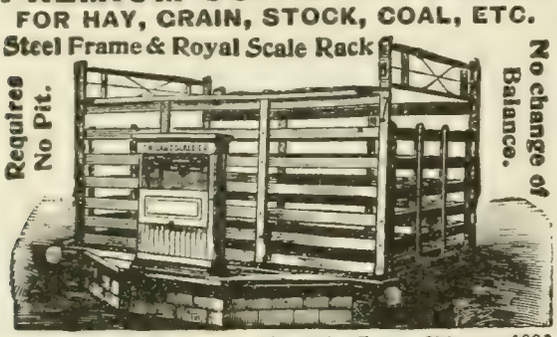

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WANTED—April number, 1904, of TECHNICAL WORLD. Will pay cash. Address JOHN MORTON, Hawkeye, Iowa.

FOR SALE

COMPLETE set of castings to build a 1½-H. P. gasoline bicycle motor. Accurate blueprints furnished. Can be finished on an 8-inch lathe. No special tools or previous experience required. Price per set, $8.00. Further information freely furnished.—CLIMAX ELECTRIC WORKS, New Salem, Mass.

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"WE WERE bounding along," said a recent traveler on a local South Africa single-line railway, "at the rate of about seven miles per hour, and the whole train was shaking terribly. I expected every moment to see my bones protruding through my skin. Passengers were rolling from one end of the car to the other. I held on firmly to my seat. Presently we settled down a bit quieter; at least, I could keep my hat on, and my teeth didn't chatter.

"There was a quiet-looking man opposite me. I looked up with a ghastly smile, wishing to appear cheerful, and said:

"'We are going a bit smoother, I see.'

"'Yes,' he said; 'we're off the track now.'"

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WE would like to ask you if your advertising literature is what it ought to be to give the greatest possible returns for the time and money expended—and whether you know that

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A CLERGYMAN was caught in a severe gale. The water was exceedingly rough, and the ship persistently buried her nose in the sea. The rolling was constant, and at last the good man got thoroughly frightened. He asked the captain if he could not have prayers. The captain took him by the arm and led him down to the forecastle, where the tars were singing and swearing. "There," said he, "when you hear the swearing you may know there is no danger." He went back feeling better, but the storm increased his alarm. Disconsolate and unassisted, he managed to stagger to the forecastle again. The ancient mariners were swearing as ever. "Mary," he said to his sympathetic wife, as he crawled into his berth after tacking across a wet deck, "Mary, thank God they're swearing yet."—*Life.*

Resemblances

SMALL BOY (just home from school): "Mamma, Miss Simpson says I'm descended from a monkey."

HIS MOTHER (glancing severely at her husband): "Not on my side, darling."—*Harper's Weekly.*

Made a Hit

GILES: "My wife can drive nails like lightning."

MILES: "You don't mean it!"

GILES: "Sure I do. Lightning, you know, seldom strikes twice in the same place."—*Chicago Daily News.*

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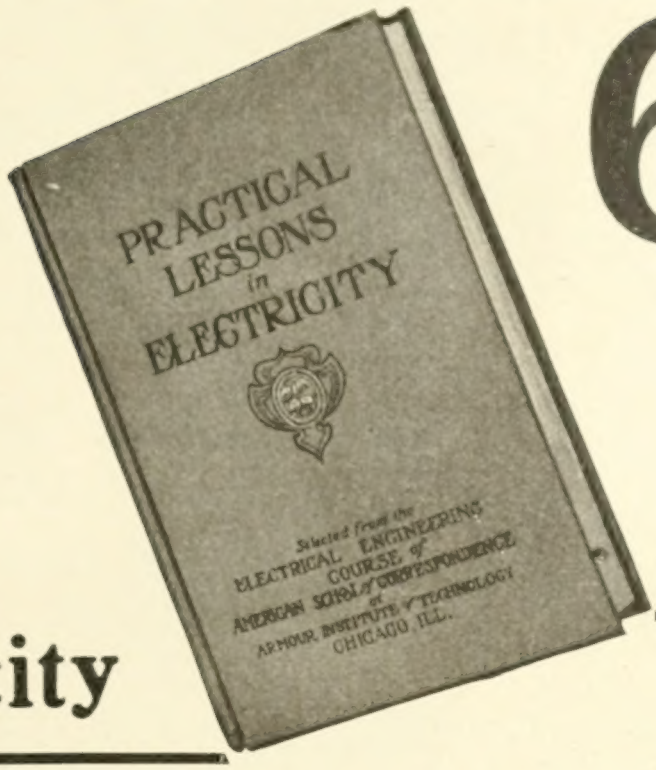

60c

If wanted by mail send ten 2-cent stamps to cover cost of delivery, otherwise book will be sent collect.

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Over 100 diagrams, sections, tables, formulae and full-page illustrations.

MANY people believe Electricity cannot be taught outside the classroom. To demonstrate the standard, scope and methods of our instruction we have bound up four representative instruction papers in our Electrical Engineering course in a handsome cover under the title of

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making a book of 300 pages, 8x10 inches in size, bound in green art buckram. Until May 30th we will send one copy for 60 cents (the actual cost of binding) to every reader of The Technical World sending us **the names of three persons** whom he knows to be interested in one of the courses mentioned below. (State course in which interested.) Address Room 137.

The book is easily worth $2.00, and we make this offer because we know that an inspection of our text-books will be convincing evidence of the practical value of our instruction.

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ELECTRIC WIRING, by H. C. Cushing, Jr. (author of "Standard Wiring"); Dynamo Installation; The Switch Board; Lightning Arresters; Motor Installation; Tables; Transformers; Three-Wire System; Poles and Pole Setting; Inside Wiring; Arc Light Wiring; Conduit Work; Fixture Wiring; Cut-Outs; Switches; Distribution of Light; Arc and Incandescent Systems; Fuses; Inspection; etc.

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ELEMENTS OF ELECTRICITY: Magnets, Experiments with Magnets; Magnetizing Steel; Conductors and Insulation; Electric Machine; Leyden Jar; Voltaic Cell; Types of Cells; Electromagnets; Induction Coil; Electrolysis; Electrotyping and Electroplating; The Telephone; The Telegraph, Sounder, Alphabet; Key, Battery, Relay; etc.

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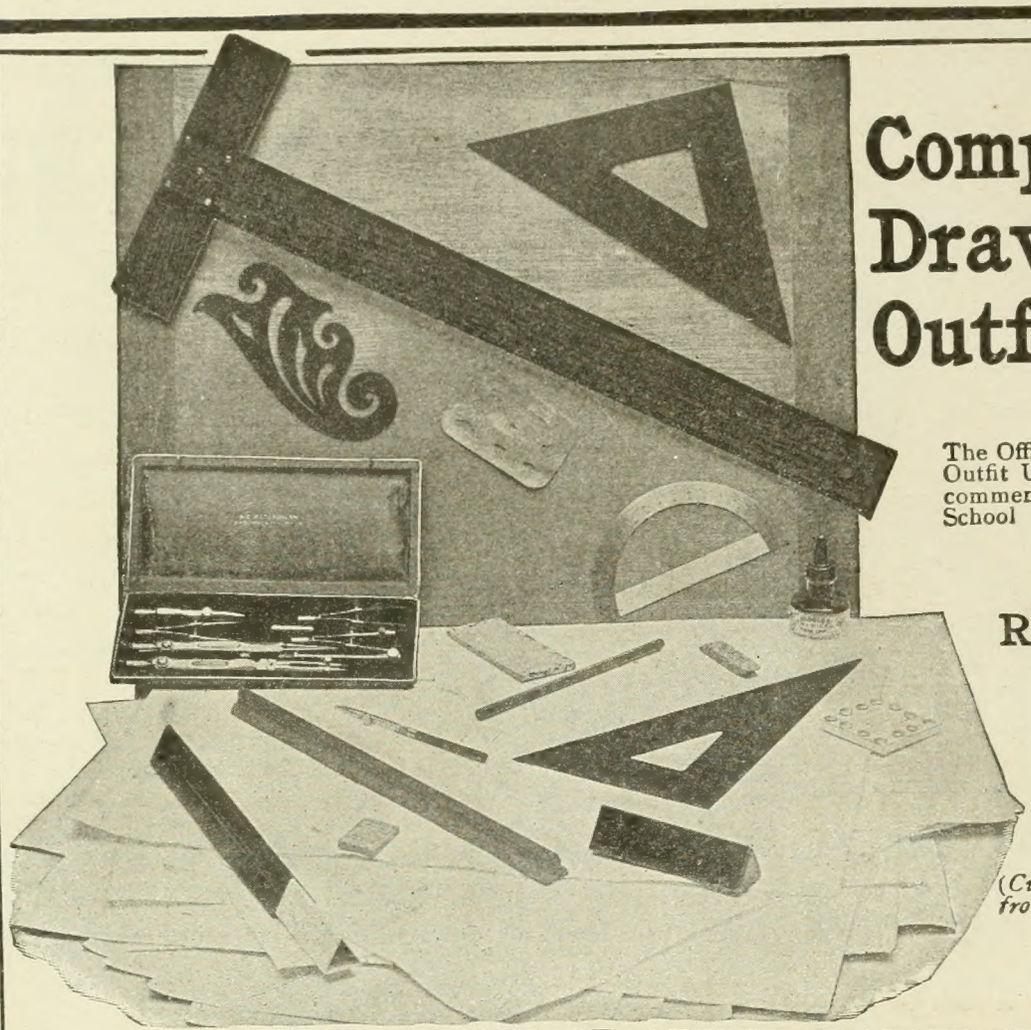
At Armour Institute of Technology
Chicago, Ill.



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One steel spring bow pen, 3¼ inches long, with needle point.

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One adjusting key.

Retail Price of Instruments, $6.90

Total Value of Complete Outfit, $15.34

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One Drawing Board, 19x25 inches, seasoned pine, with end battens, tongued and grooved, shellac finish,	$1.50
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One 30°x60° Transparent Triangle, 10 inch,	.70
One 12-inch Triangular Boxwood Scale, engine divided; graduated 3-32, 3-16, 1-8, 1-4, 3-8, 3-4, 1-2, 1 1-2, and 3 inches to the foot, and one edge inches and 16ths, with case,	1.00
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One Faber's Ink Eraser, No. 1075,	.05
One Faber's Pencil Eraser, No. 111,	.05
One dozen Thumbtacks,	.20
Nine sheets Whatman's handmade, cold pressed, Drawing Paper, 13½x20 inches,	.54
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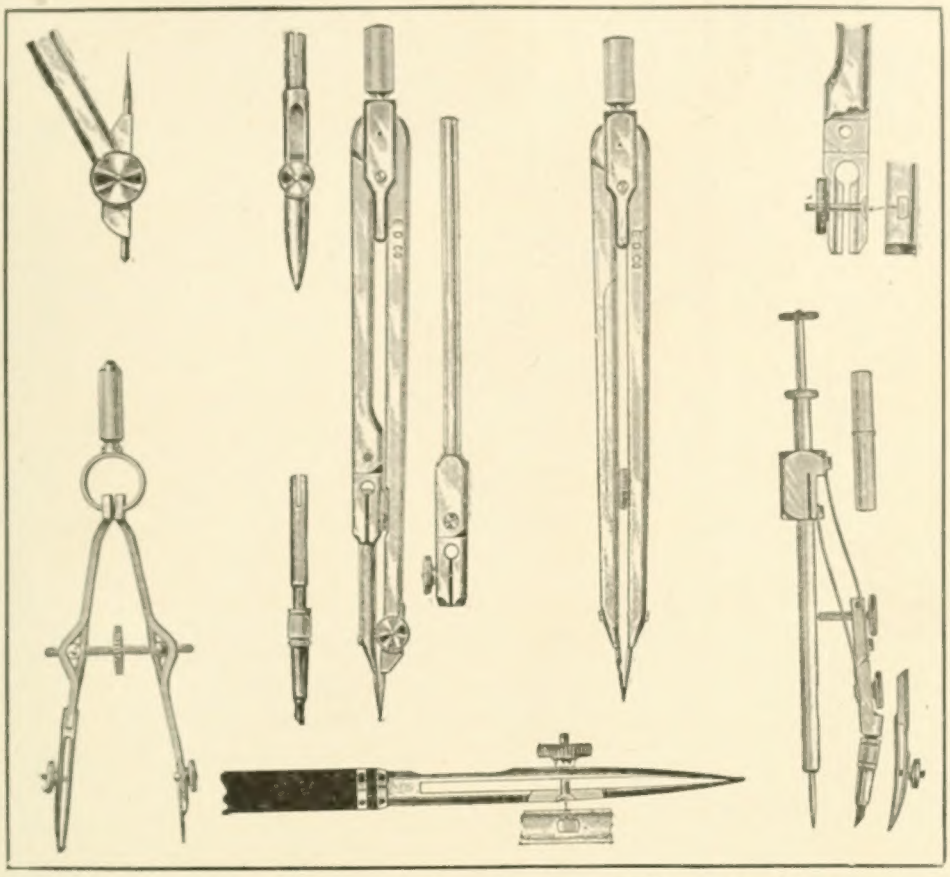

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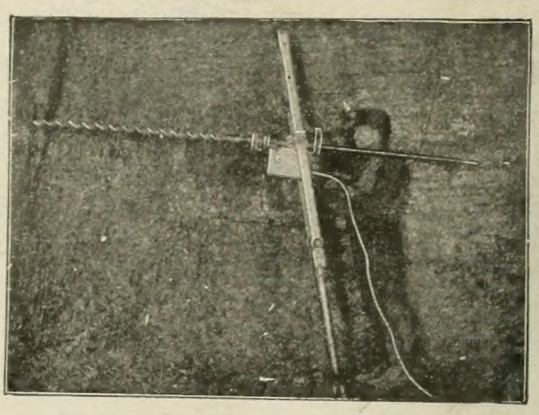

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